Physical and Chemical Data Collected in the Bering and Chukchi Seas in July 2003

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2008

Canadian Data Report of
Hydrography and Ocean Sciences 171

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

Canadian Data Report of Hydrography and Ocean Sciences

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Les établissements de l'ancien secteur des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports en décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du rapport numéro 1 en janvier 1982.

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by

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Cat. No. Fs 97-16/171 ISSN 0711-6721

Correct citation for this publication:

Carmack, E.C., McLaughlin, F., van Hardenberg, B., Gatien, G., Xie, L., Grebmeier, J. M., Cooper, L. W., DiTullio, G. R. and Lee, P. A., 2008. Physical and chemical data collected in the Bering and Chukchi Seas in July 2003. Can. Data Rep. Hydrogr. Ocean. Sci. 171: vii +69p .

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Abstract

Carmack, E.C., McLaughlin, F., van Hardenberg, B., Gatien, G. Xie, L., Grebmeier, J. M., Cooper, L., DiTullio, G. R., and Lee, P. A., 2008. Physical and chemical data collected in the Bering and Chukchi Seas in July 2003. Can. Data Rep. Hydrogr. Ocean Sci. 171: vii + 69p.

Physical and chemical water properties in the Bering and Chukchi Seas were measured as part of the Joint Western Arctic Climate Study (JWACS) in a science expedition in July of 2003 aboard the *CCGS Sir Wilfrid Laurier* during the ship's transit to the Arctic (Institute of Ocean Sciences Cruise Number 2003-18). Objectives of the program were to investigate changing conditions on the continental shelf of the Bering and Chukchi Sea, inter-annual variability of water properties, distribution and concentration of bacteria and benthic parameters from sediment sampling.

This data report presents a cruise summary, lists the parameters sampled, the analysis methods used and results obtained for physical and chemical properties from the data and samples collected in CTD/rosette casts. The CTD profiles include data for pressure, temperature, salinity, light transmission and fluorescence. The rosette water sample analysis results include concentrations of salinity, nutrients, chlorophyll, oxygen isotope (^{18}O), barium, particulate DMSP and phytoplankton pigments. Bottle samples collected but not included in this report are listed. The report includes a diagram of the instrumented mooring deployed.

Résumé

Carmack, E.C., McLaughlin, F., van Hardenberg, B., Gatien, G., Xie, L., Grebmeier, J. M., Cooper, L., DiTullio, G. R., and Lee, P. A., 2008. Physical and chemical data collected in the Bering and Chukchi Seas in July 2003. Can. Data Rep. Hydrogr. Ocean Sci. 171: vii + 69p.

En juillet 2003, lors d'une expédition scientifique vers l'Arctique (croisière numéro 2003-18, Institut des sciences de la mer) à bord du NGCC Sir Wilfrid Laurier, on a mesuré les propriétés physiques et chimiques de l'eau de la mer de Béring et de la mer de Tchoukotka dans le cadre de L'Étude conjointe du climat de l'ouest de l'Arctique (JWACS). Le programme visait l'étude des conditions changeantes du plateau continental de la mer de Béring et de Tchoukotka, la variabilité interannuelle des propriétés de l'eau, la distribution et la concentration des bactéries et les caractéristiques benthiques d'échantillons de sédiment.

Ce rapport de données présente un sommaire de la croisière, énumère les paramètres prélevés, les méthodes d'analyse utilisées et les résultats obtenus pour les propriétés physiques et chimiques des données et des échantillons prélevés à l'aide de la sonde CTP/rosette. Les profils de CTP incluent des données de pression, température, salinité, transmission de lumière et fluorescence. Les résultats de l'analyse des échantillons d'eau prélevés avec la rosette incluent la concentration de sel, d'éléments nutritifs, de chlorophylle, d'isotope de l'oxygène (18O), de baryum, de DMSP particulaire et de pigments phytoplanctoniques. Les échantillons prélevés dans les bouteilles mais non inclus dans ce rapport sont énumérés. Le rapport inclut un diagramme de l'instrument amarré qui a été déployé.

Acknowledgements

We would like to thank the captain, officers and crew of the *CCGS Sir Wilfrid Laurier* for their able and willing assistance during the cruise. Their extra efforts beyond the call of duty greatly contributed to the success of this science expedition.

This work was supported by the Department of Fisheries & Oceans Canada (DFO), the US National Science Foundation (NSF) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

1. INTRODUCTION

The Joint Western Arctic Climate Study (JWACS) is an ongoing collaboration between DFO researchers from the Institute of Ocean Sciences, and scientists from JAMSTEC, from the University of Tennessee at Knoxville (NSF/UTK), the Seattle Pacific Meteorological & Environmental Laboratory (NOAA/PMEL) and the University of Alaska Fairbanks (UAF), to conduct hydrographic surveys and benthic & water column sampling in the Bering and Chukchi Seas. Principal investigators in this project were Eddy Carmack (DFO), Fiona McLaughlin (DFO), Jackie Grebmeier & Lee Cooper (UTK), Jim Overland (NOAA/PMEL) and Terry Whitledge (UAF).

The region sampled in this part of the JWACS study included the shelf areas of the Bering and Chukchi Seas that form the connection between the North Pacific and the Arctic Ocean. The main focus of the program was to study ocean climate variability and the relationships between the physical environment and biota north and south of the Bering Strait:

- To measure the impacts of climate variability on the physical environment and the corresponding biological responses by sampling changes in water mass properties, biological distributions and ocean circulation.
- To understand the impacts of changes in water temperature structure and extent of sea ice on fresh water distribution from a suite of geochemical markers to quantify freshwater components and investigate water mass pathways.
- To investigate distributions and abundances of bacteria and zooplankton.

This program was conducted aboard *CCGS Sir Wilfrid Laurier* from 11 to 21 July, 2003 (Institute of Ocean Sciences mission number 2003-18). A 10-member science team conducted CTD profiling and rosette sampling, deployed an instrumented mooring, and conducted benthic sediment sampling at stations. The cruise provided the opportunity to re-visit stations along the south-to-north section through this highly productive shelf region.

This report presents a summary of all the onboard activities and describes the analytical methods and results from the CTD and water chemistry program conducted all participants, with focus on reporting the data collected by the team from the Institute of Ocean Sciences.

1.1 FIELDWORK SUMMARY

The science program was conducted in the Bering and Chukchi Seas during the ship's annual transit from Victoria, BC to the Canadian Arctic. The main program consisted of the collection of profile data and discrete water samples with the CTD/rosette system, benthic samples using a van Veen sediment grab and a HAPS core, deployment of a current meter mooring, and vertical net hauls for zooplankton. The cruise accomplishments are summarized below. Specific location and time of events are listed in the appendices.

The following data collection tasks were done during the cruise:

32 CTD/rosette casts:

- 6 casts in a section onto the continental shelf in the central Bering Sea,
- 16 casts at benthic sampling sites,
- 5 casts in a section across the eastern half of the Bering Strait,
- 4 casts at bio-diversity stations in the Chukchi Sea
- 1 cast at the instrumented mooring site.

16 Benthic Sampling stations: at each station (in addition to CTD/rosette):

- 5 van Veen sediment grabs,
- 3 Haps core samples,
- bottom water from ctd/rosette casts for respiration incubations.

1 Instrumented mooring deployment: outfitted at discrete depths with

- 1 Nitrate meter,
- 2 Seacats, each with fluorometer,
- 2 Current meters,
- 2 Microcats and
- 8 Temperature sensors (4 with pressure sensor).

Site survey at Little Diomede Island: at each of 13 stations:

- water sample at bottom and surface, at 2 separate times (total 52 samples),
- YSI salinity & temperature profiles,
- UV light profiles.

Instrumentation

1. A CTD system equipped with sensors for pressure, temperature, conductivity, transmissometer, fluorometer and dissolved oxygen.
2. The Rosette water sampler with 12 bottles, each 8 liters, generally closed at 5 meter intervals; samples were drawn from these to determine salinity,

nutrients (nitrate, silicate and phosphate), chlorophyll-a (chla), particulate DMSP ($DMSP_p$), phytoplankton pigments, algal species, oxygen isotope (^{18}O), and barium.

3. Underway sampling for chla, phytoplankton pigments and $DMSP_p$ was done in the ship's lab from the near-surface seawater loop.

1.2 STUDY AREA

The station locations are shown in the figure below. Position information was collected from the ship's GPS. Science station locations are listed in the appendix.

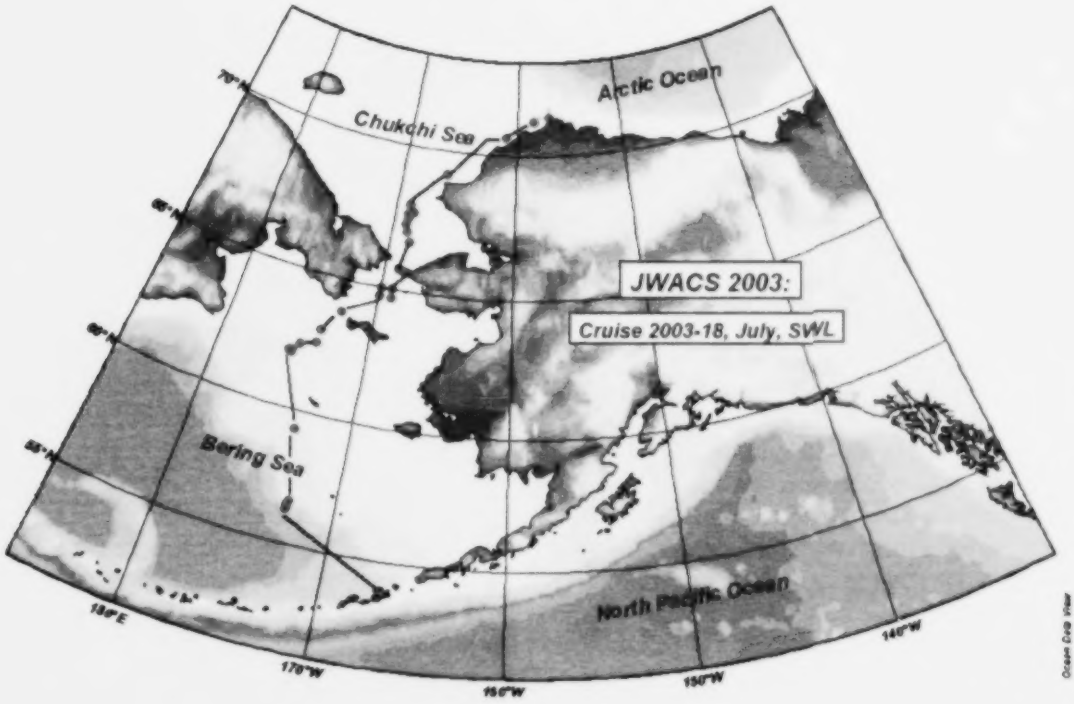

Figure 1. Map of science station locations.

Data and samples were collected in the Bering and Chukchi Sea along the ship's track:

nutrients (nitrate, silicate and phosphate), chlorophyll-a (chla), particulate DMSP ($DMSP_p$), phytoplankton pigments, algal species, oxygen isotope (^{18}O), and barium.

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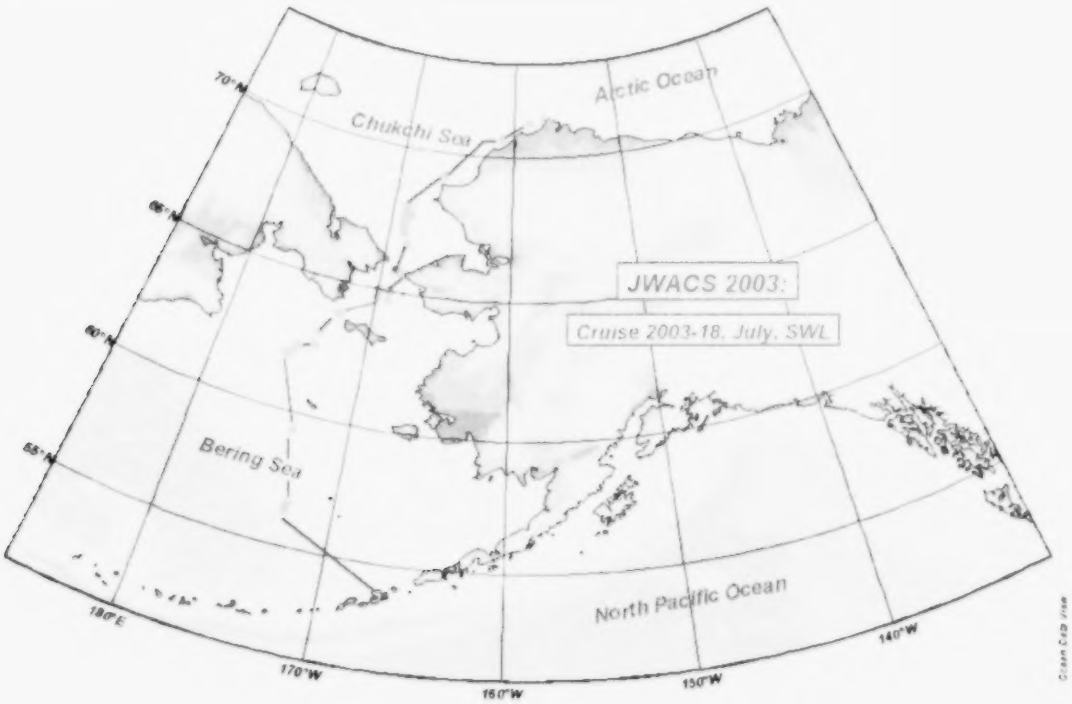

Figure 1. Map of science station locations.

Data and samples were collected in the Bering and Chukchi Sea along the ship's track.

- Along a short CTD section in the central Bering Sea, from deep water onto the shelf,
- At a set of 5 benthic stations in a biological hotspot south of St. Lawrence Island,
- The instrumented mooring was deployed near these latter stations,
- At a set of 4 benthic stations in a hot spot south of Bering Strait,
- At a section of 5 stations across the eastern part of the Bering Strait,
- At a set of 13 stations off Little Diomede Island where an 8-hour survey was done for the ocean observatory project set up there,
- At a set of 7 stations north of the Bering Strait in a biological hotspot, and
- At a set of 4 stations bio-diversity stations between the previous set and Barrow.

2. METHODS AND ANALYSIS

2.1 SCIENCE PLATFORM: CCGS *Sir Wilfrid Laurier*

The Canadian Coast Guard icebreaker *Sir Wilfrid Laurier*, stationed in Victoria BC travels each summer to the Arctic to provide assistance to shipping and to northern communities. It carries several rigid-hull inflatable boats and, in the Arctic, a helicopter for ice reconnaissance support. The ship is well equipped for science operations: the well-deck has a large ship's crane that can be used to deploy instrumented moorings, an A-frame and winches for hydro-wire used in plankton net hauls and in sediment grabs and cores, a winch with heavy cable for dragging operations, and a lab container with power, heat & communications for set-up of mooring instrumentation or handling plankton samples. For science samples, the ship's hold has a chest freezer, a -80 low-temperature freezer and a walk-in cooler. The main laboratories are located on the boat deck, where the CTD/rosette is launched and recovered by hydraulic boom from an enclosed area midship's, using a winch with conducting-cable located on the deck above. The main wet/dry lab has a fridge/freezer for science samples, a fume hood, and a seawater loop for underway sampling. There is room for additional lab containers on the well deck and boat deck. Expendable XBT and XCTD probes can be launched from aft locations while underway to obtain profiles of temperature and/or salinity. Besides the navigation sounders the ship also has a Simrad EK500 deep sounder for science operations. Weather parameters are collected by an automated AVOS sensor system and transmitted to the global grid, and an internal computer network provides access to position data.

2.2 FIELD SAMPLING: CTD/ROSETTE CASTS

CTD/rosette casts were conducted at 33 stations with a Seabird SBE25/33 system mounted on a SBE32 Carousel 12-bottle water sampler.
The SBE25 CTD collected profile data at 8Hz, from the standard sensors for pressure, temperature and conductivity, and from external sensors measuring dissolved oxygen levels, light transmission, and chlorophyll concentrations from fluorometer readings. Sensor serial numbers and calibration dates are included with data processing notes below.

After the ship stopped at the requested station location, a typical CTD/rosette cast was done by lowering the CTD system at 1 m/s to the maximum depth, then raising the system to stop at successive requested water sampling depths to close a bottle. Most of the sampling during this cruise was done in shelf regions with water depths ranging from 40 to 70 meters.

From each rosette bottle, samples were taken for chemical analysis: salinity, dissolved oxygen, nitrate (NO_3), silicate ($Si(OH)_4$), phosphate (PO_4), chlorophyll-a (Chla), $DMSP_p$, phytoplankton pigments, oxygen isotope (^{18}O), and barium (Ba).

2.2.1 Reported Data

2.2.1.1 Downcast CTD Files

The CTD profile data were produced following standard IOS protocol by applying the most recent calibration values for each sensor to raw hexadecimal cast data to convert them to physical units. The data were inspected by plotting, and standard CTD parameters were processed using Seabird recommended steps to de-spike, to adjust for differences in time response and time lags, then to recalculate the derived salinities and as final step, to depth-average them to 1 db. The files so produced include all variables collected. Note that data from the external sensors (dissolved oxygen, fluorometer and transmissometer) have not been calibrated against known standards. Data collected alongside the ship from the surface down to 3 db was very noisy, considered to be unreliable and therefore removed.

2.2.1.2 Chemistry

All water sample data are archived in a spreadsheet file with station location and time, CTD data at sample depths, and water sample analysis results referenced to a unique sample number. The lag between CTD reading and water

in the bottle was determined by examining the CTD and bottle salinity in the high gradient near-surface water (upper 300m). The CTD data entered with the water sample data are 1 second averages from the downcast matched to trip depths during upcast bottle trip depths.

Dissolved oxygen, chlorophyll and DMS samples were analyzed on board during the cruise. Salinity, nutrients, ammonia, barium, oxygen isotope, $DMSP_p$ and phytoplankton pigment samples were analyzed after the cruise at shore-based laboratories.

2.3 CTD DATA ACQUISITION, PROCESSING AND VALIDATION

2.3.1 Overview/Highlights

The CTD data acquisition program was started and the CTD turned on before lowering the system over the side. To ensure that the light transmission values would be consistent, the transmissometer lenses were rinsed before each cast. The system was soaked just below the surface for 1 to 2 minutes to provide time for the delayed pump start and to eliminate start-up transient values from the sensors. CTD data acquisition was stopped after the CTD was brought up from the water in order to record final out-of-water sensor values.

After lowering the CTD/rosette below the sea surface from a station at the rail, the Hawboldt CTD winch was controlled by the CTD operator: at the data acquisition station the SBE33 deck unit was used to acquire the sensor data and to display data during the cast. The Scantrol winch control unit, programmed to provide constant descent and retrieve speeds, was used to start the descent and to stop during the upcast at selected depths and, after a 30 second wait, sequentially close an 8-litre sample bottle.

The DO sensor did show problems associated with its slow time-response, and this was particularly serious in parts of profiles with large DO gradients. The DO values are considered unreliable and not included. The fluorometer data are nominal and unedited. Chlorophyll data from bottle samples did not provide a useful method to verify the fluorometer calibration. There were no independent data available to verify the transmissometer values.

The SBE-5T pump on the CTD pulls water past the temperature sensor, then through the conductivity cell and through 10.5" of 3/8" ID tygon tubing past the membrane in the dissolved oxygen sensor. The measured flow rate was 14.8 mL/s, compared to nominal value with T-C duct of 18 mL/s.

Table 1. CTD sensor accuracy for 2003-18

Sensor	Accuracy	Calibration Date (SBE)	Correction to SBE calibration	Comment
Pressure SBE29-0464	±1 db	27 Dec 2002	+0.6 db offset	Max 1024 dbar
Temperature SBE03-4115	0.001°C	31 Dec 2002	None	
Conductivity SBE04-2607	0.003 mS/cm	31 Dec 2002	-0.0007 mS/cm.	From water sample comparisons
Salinity	0.005 PSU	N/A	PSU	Based on conductivity calibration
Oxygen SBE43-0052	2% of saturation	06 Aug 2001	Data unverified and considered poor	D.O. data not included
Transmission SeaTech #139	NA	None	None	Path length 0.25m
Fluorescence Seapoint #2336	NA	23 Apr 2001	None	Gain used: 30X (0-0.5 µM/L)

2.3.2 Acquisition and Processing Steps

CTD data were acquired in real -time through a conducting cable from the CTD to a PC running Seabird's Seasave software on a PC computer. The ship's GPS position was added to the header at the start of each cast. Upon completion of the cast, the raw data were copied to a separate PC for further processing with Seabird SBEDataProcessing software. This provided the raw CTD values at bottle trip depths and the initial 1 db averaged downcast profiles. The same cast data was also recorded internally in the CTD and downloaded after several casts as back-up.

The standard Seabird processing steps were: visual inspection of raw data plots, removal of spikes, low-pass filtering to smooth noise in the data, alignment of sensor timing to compensate for differences in time response and for physical separation along the pump path; a correction for the thermal mass of the conductivity sensor; removal of effect of descent variations or reversals; calculation of salinity from corrected pressure, temperature and conductivity; averaging data to 1 db intervals; and calculation of other derived properties as required (density, potential temperature etc.).

Further processing was done after the cruise with the IOSshell routines, using post-cruise calibration checks and analyzed salinity values for independent verification of the CTD data.

2.3.3 Pressure Calibration

Stated accuracy for the SBE29 pressure sensor: 0.1% of full scale (1024m) is 1m. The first "in-water" pressure values for most casts ranged from -0.2 to -1.0db with most of those between -0.5 and -0.7db; the last "in-water" values were more scattered, ranging from -0.5 to -1.3db. For the deepest casts, these "surface" values differed between cast start and end by 0.2 to 0.3db; the resolution of the pressure sensor is about 0.2db. No significant hysteresis was found. No post-cruise pressure calibration was done, but experience from previous calibrations showed a drift of about 1db per year, corresponding to a further drift of about 0.6db since the last calibration at the time the data was collected, as confirmed by the data. An offset of 0.6 db was applied as correction to the pressure data, and the configuration files were adjusted accordingly.

2.3.4 Temperature Calibration

Stated accuracy for the SBE03 temperature sensor: 0.001 °C
Results suggest this is appropriate for this data set. Pre- and post-cruise calibrations show negligible sensor drift <0.0001 °C/year. The data presented were calibrated with the pre-cruise laboratory calibration coefficients. The only corrections made were removal of data spikes No adjustments were performed other than interpolation.

2.3.5 Conductivity Calibration

The stated accuracy for the SBE04 conductivity sensor is 0.003 mS/cm The conductivity was shifted relative to temperature by 1 record (a lag of 0.125 sec) to minimize density inversions appearing in TS diagrams in profiles with strong gradients. This did not correct errors in sensor matching where temperature gradients were very large. Drift in annual calibration values over several years varied from 0 to -0.0001 mS/cm.

2.3.6 CTD Salinity Calibration

Base on the stated accuracies for T and C sensors, the salinity accuracy is ±0.005 psu. However, in profiles with strong temperature gradients it should be

considered ±0.02 psu since salinity was edited heavily. CTD salinity was recalculated from the calibrated filtered and lagged conductivity, temperature and pressure data. Comparison with sample bottle salinities showed that salinities derived from CTD sensors were high by about 0.002 PSU. The majority of casts was done in shallow shelf water, where noise in the results was to be expected.

Comparison of salinity from bottle samples with values computed from the CTD sensors was noisy, as expected in the highly variable upper layer. Greatest variability in salinity comparison was for stations BRS1 to BRS5 in the section across the eastern part of Bering Strait. Data from the few sample values below 125 m show that salinities from the CTD are high by about 0.002 psu. From the limited range of depths for these data there is no evidence of time or pressure dependence.

2.3.7 Data adjustment

Records were removed that appeared to be corrupted by shed wakes or overturning caused by the presence of the ship. Salinity was cleaned where there were spikes or "overshoots" suspected to be due to misalignment of T and C. The cruise went through a region with some very large temperature gradients in summer (3-4 °C in 1-2 meters depth, some >8C° in 10m), resulting in large errors in salinity likely from temperature effects on the conductivity sensor.
In regions of active mixing some instabilities could be real interleaving features; these were left unedited. The salinity gradients were usually fairly low, so even with editing, the resultant error would generally be within ±0.02 psu. Away from the large gradients the salinity is considered ±0.005 psu. For some casts the instabilities in the top 15db looked likely due to ship action so the data was removed. Where the CTD descent rate near the bottom slowed suddenly to near-zero, instabilities were likely caused by shed wakes and those records were removed. Relevant editing details are included in the headers of every data file.

2.3.8 SBE-43 Oxygen Calibration

The stated SBE43 dissolved oxygen sensor accuracy was 2% of saturation. There were no oxygen data from bottle samples available for verification of the sensor calibration. The processing results appeared poor, and these data were not included in the final processed files, but are available as raw data at IOS.

2.3.9 Fluorescence data

The output from the Seapoint fluorometer sensor on the CTD is a scaling of fluorescence to chlorophyll-a concentrations. The range setting for the fluorometer of 0-5 µg/L caused the signal to saturate for high plankton concentrations. At stations near, across and north of the Bering Strait, bottle concentrations were often above the saturation value of the fluorometer sensor, and in such casts no good estimate could be obtained for the depth of the chlorophyll maximum.

The plot below compares the values from the CTD fluorometer with those from analysis of bottle Chla: At low values of bottle Chla, the instantaneous fluorometer value was often higher than that from bottle samples. Where the CTD value is below this saturation value, the mean and standard deviation of the difference between them are 0.62 and 1.39 respectively. The plot shows a lot of scatter and fluorometer saturation even at low concentrations from bottle data. Based on this data comparison, no calibration adjustment was applied to the fluorometer data. Note that the fluorometer was not pumped.

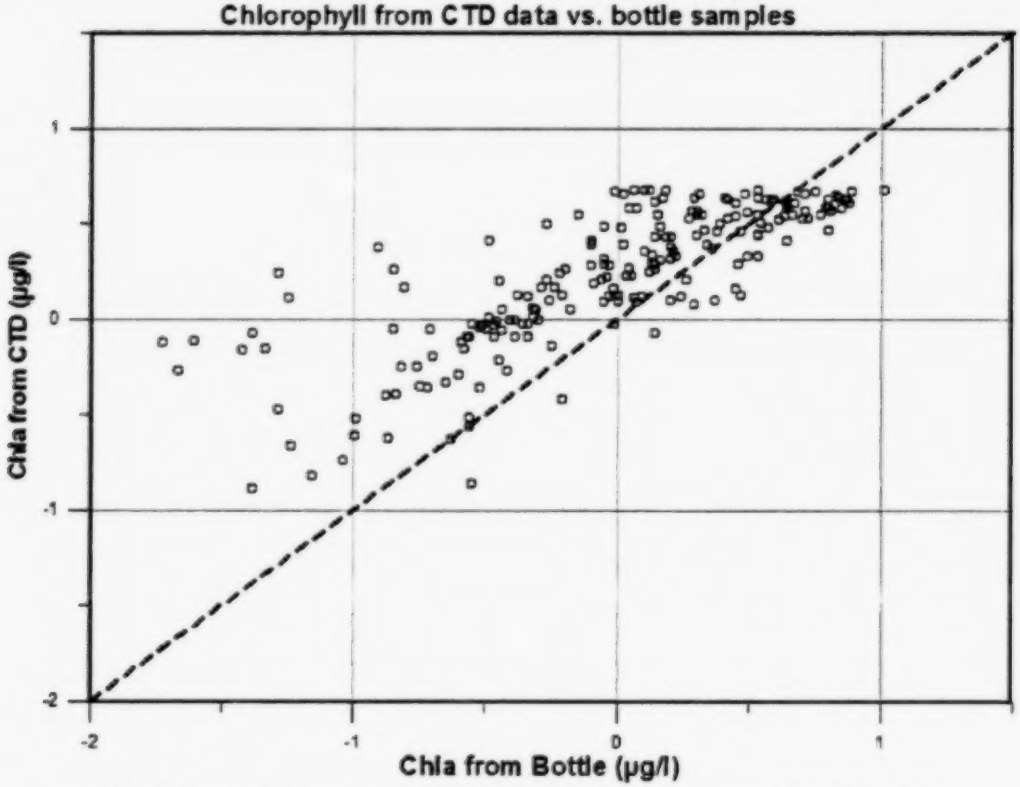

Figure 2 Comparison of chlorophyll-a from bottle samples with values from the CTD fluorometer.

2.3.10 Light transmission sensor data

The Seatech transmissometer was last calibrated on 23 April 2001 against original factory calibration by measuring the voltage output in air with open and blocked path. The CTD/rosette logbook entries only confirm that the lens windows were wiped at two casts. Therefore the light transmission values included in the archived data may have been affected negatively and should be treated with caution, and considered qualitative rather than quantitative.

2.3.11 CTD Data at Bottle Depths for Water Chemistry File

Bottle trip files (*.bl) were generated by the CTD acquisition system from deck unit output and contain entries for bottle number, date & time fired and associated CTD scan number. The SBE processing software was used to create bottle summary files with averaged CTD values at trip depths using a 5 second window around bottle trip time. The expected values for data channels appear reasonable.

2.4 WATER CHEMISTRY SAMPLING AND ANALYSIS

2.4.1 Overview/Highlights

Sampling from the rosette bottles was done immediately after each cast in the rosette enclosure, following the supplied protocols for rinsing, filling and capping of the pre-labeled sample vials & tubes. Chlorophyll-a and dissolved oxygen samples were analyzed on board, and DMSP samples filtered then stored. Other samples were sent after the cruise for analysis in laboratories on shore. Samples collected for the following water property measurements are listed in Table 2.

Salinity (Carmack / McLaughlin) total of 64 samples including 8 duplicates:

- from all casts (except casts 2 and 9) a single salinity sample was collected at depth or in well-mixed part of profile to check CTD calibration,
- at stations BRS1-5 (casts 18-22) at the following nominal depths: 1m, 5m, 10m, 25m, 35m and bottom.

Nutrients (NO_3+NO_2, $Si(OH)_4$, PO_4) (McLaughlin): total 29 samples (in duplicate)

- At stations BRS1-5 along the Bering Strait section (casts 18-22), at the following nominal depths: 1m, 5m, 10m, 25m, 35m and bottom.

Nutrients (NO_3, $Si(OH)_4$, PO_4, and NH_4 (Grebmeier / Cooper): 61 samples,

- All stations from the surface and the deepest bottle, plus at the Bering Strait section one additional sample from intermediate depth,

Chlorophyll-a (Grebmeier / Cooper): 256 samples

- From bottles surface to 100m depth,

Barium (Guay): total 29 samples

- From 1m, 5m, 10m, 25m, 35m, and bottom at the 5 Bering Strait stations

Delta-^{18}O (Cooper): total 29 samples

- 10 analyzed, (surface & bottom sample at the 5 Bering Strait stations)

Chlorophyll-a (Grebmeier): total 256 samples,

- at all benthic sites: stations SLIP1-5 (casts 6-12), stations UT-BS1,2,4,5 (casts 14-17), and at stations UTN1-7 (casts 23-29)
- at Bering Strait Section, stations BRS1-5 (casts 18-22).

Particulate DMSP: total 336 samples

- 252 samples were collected from most rosette casts at all depths as per table 2, and
- 84 samples from the near-surface seawater loop in the main lab aboard.

Phytoplankton pigments: 336 total, same details as the particulate DMSP.

Table 2. Rosette Sample Summary

Parameter	Nr of Samples	In casts (total 33)	Depths	Analysis	Investigator
Salinity	64	All except casts 2 & 9	All depths at stns BRS1-5, others 1/cast	Lab	Carmack (IOS)
Nutrients (PO_4, NO_3, SiO_4)	58	18-22	BRS1-5 all depths	Lab	McLaughlin (IOS)
Chlorophyll-a	56	All except 2, 4, 30-33	Most depths	Ship	Grebmeier (UTK)
^{18}O	10	18-22	2/cast (top & bottom)	Lab	Grebmeier & Cooper (UTK)
Barium	29	18-22	BRS1-5 all depths	Lab	Chris Guay (OSU)
Nutrients & Ammonia	61	all except 2,4,30-33	2 (sfc & deep), but 3 at BRS1-5: sfc, 25m, & bottom	Lab	Grebmeier (UTK)
$DMSP_p$ & phyto.pigment	336	all except 2,4,9,31-33	All depths and seawater loop	Lab	DiTullio (CofC)

2.4.2 Laboratory Methods

The precision of the methods was estimated by analyzing replicates and is expressed as the pooled standard deviation s_p, using the equation:

$$s_p = \sqrt{\frac{\sum (c(1)-c(2))^2}{2n}}$$

where *c(1)* and *c(2)* were the concentrations of duplicate samples and *n* refers to the number of pairs.

2.4.2.1 *Bottle Salinity*

Salinity samples were collected from the Niskin bottles immediately after the rosette cast. Sample bottles and caps were rinsed 3 times before filling. Samples were stored in the ship's lab at room temperature until returned to the Institute of Ocean Sciences.

Salinity samples were analyzed after the cruise using a Guildline Autosalinometer Model 8410A (SN# 59724) following the procedure & methods outlined in standard IOS protocol. The salinometer was standardized against IAPSO Standard Seawater (OSIL, batch P141). Standby at start was 1.323411, after 23 samples 1.323415, final 1.323413; K_{15} = 0.99993 and tank temperature 22 °C. Pooled standard deviation from 5 duplicate samples was 0.0037 PSU. Data are reported in practical salinity units (PSU) (*Lewis and Perkin*, 1978).

2.4.2.2 *Nutrients*

Water samples for nutrient determination were collected into glass and polystyrene test tubes after the tube and cap had been rinsed three times with the sample water.

The nutrient samples (silicate, nitrate (NO_3 + NO_2) and orthophosphate) were kept frozen and analyzed after the cruise. Nutrients collected near surface and bottom at most stations (Grebmeier, UTK) were analyzed at the Marine Science Institute of the University of California, Santa Barbara using a Lachat Instruments QuikChem 8000 auto-analyzer.

Nutrient samples from all depths at the Bering Strait section were analyzed at the Institute of Ocean Sciences (IOS) using a three channel Technicon Auto Analyzer following the method described by Barwell-Clarke and Whitney (1996). At IOS, reagents were prepared as needed, and a 3.2% w/v solution of sodium chloride (Sigma) was used to prepare standards and to rinse between samples. One cadmium column was used for all samples. The Auto Analyzer was rinsed with 3N NaOH and 1N HCl for 5–7 minutes and rinsed with DMQ water for > 20 minutes after all reagents and salt were disconnected. Data was logged by analog (chart) and also digitally on a computer using the IOS

"Newget" program. DMQ water was analyzed before the initial standards and after the last standard set as a check on the chemical blank. Standards (low, medium and high) were prepared using a freshly prepared 3.2% salt solution. and analyzed at the beginning and end of the day's run. The standard range brackets the expected nutrient levels in the samples.

No corrections have been made to the data. When the nitrate level in surface samples is the same or slightly lower than the salt rinse solution it is reported as zero.

Table 2. Nutrient analysis replicates (n) & pooled standard deviations (Sp).

	NO_3	$Si(OH)_4$	PO_4
n	4	4	4
Sp	0.621	0.6193	0.1335

Note these values are higher than normal for frozen samples and likely due to freezing technique (i.e. not frozen upright), loose caps and potential loss of brine.

2.4.2.3 Chlorophyll-a

Samples to determine total Chlorophyll-a (>0.7µm) were drawn from the rosette bottles for depths from the surface to a maximum of 100m. The samples (250 ml) samples onto 25mm GF/F filters using low vacuum filtration. The filtration castles were rinsed down to insure cells were not left on the castle walls. The filters were put into scintillation vials with 10 ml/l of 90% acetone, labeled and put into a 4°C cooler for 24 hours. During filtration and extraction, the samples were kept dark as much as possible. After 24 hr extraction by acetone at 4°C, the samples were analyzed for chlorophyll-a in the presence of chlorophyll-b and and phaeo-pigments, using the Welschmeyer (1994) method. The fluorometer was calibrated using a Turner Design Part No. 10-850 calibrated chlorophyll standard before and after all sampling, with use of a secondary solid standard (Part No. 10-AU-904) during sampling to identify any possible instrument drift.

2.4.2.4 ^{18}O

Rosette water samples were drawn into 30 ml glass vials. Once at room temperature, the caps were retightened and wrapped with tape for storage. Oxygen isotopes were analyzed using the H_2O-CO_2 equilibration method on a Thermo Delta Plus dual inlet stable isotope mass spectrometer at the University

of Tennessee. The oxygen isotope ratio is referenced to Vienna-Standard Mean Ocean Water (V-SMOW) and reported as follows:
(V-SMOW): $\delta^{18}O = ((H_2{}^{18}O/H_2{}^{16}O)_{sample} / (H_2{}^{18}O/H_2{}^{16}O)_{VSMOW} - 1)\ 10^3$ [‰].
Internal precision of the analysis was better than < 0.05‰.

2.4.2.5 Barium

Barium samples were drawn from the Niskin into small plastic vials. Once at room temperature the caps were retightened and wrapped with Parafilm for storage. Barium samples were collected for analysis at Oregon State University, using the method described by Falkner et al. (1994), with some modifications. Results of the barium analysis are not reported here.

2.5 BENTHIC SAMPLING

At each of the benthic stations in the Bering & Chukchi Seas, bottom sediment samples were collected from a van-Veen 0.1 m^2 sediment grab and a single-barrel 0.0133 m^2 HAPS corer, (Kanneworff, E. & Nicolaisen, 1973) for sediment metabolism (respiration) measurements.

Sediment from one of the 5 van-Veen grabs was sub-sampled, some for shipboard chlorophyll analysis, others to freeze for later laboratory analysis of grain-size, TOC/TON, C-13 and 7-Beryllium. Sediment from the remaining 4 grabs were each sieved with seawater on 1mm stainless mesh for faunal collections: the remaining animals preserved in 10% seawater formalin buffered with hexamethylenetetramine for later analysis, and analyzed to determine total species abundance (#/m^2), biomass (g/m^2 and gC/m^2), number of taxa, and for the top three of those: abundance (#/m^2 and %), biomass (g/m^2 & % and gC/m^2 & %).

Two of the three HAPS core casts were used for sediment respiration experiments in incubation chambers, kept at in situ bottom temperatures and dark, to determine sediment oxygen uptake rates (mmol O_2/m^2/d). After 10 to 12 hours incubation, the cores were sieved (1 mm and 0.5 mm fractions) and the fauna packaged and preserved with formalin for later laboratory identification.

The third core was sub-sampled for vertical sediment parameters:

- sectioned at 1cm intervals down to 4 cm, sub-cores for DMSP and sediment chlorophyll (both fluorometric and HPLC), TOC, grain size, and Be-7 and Cs-137 measurements and frozen in 90 cc aluminum cans. Subsequent laboratory analyses included TOC/TON, C-13, and grain size determinations for all canned samples.

- For select stations, the full core was sectioned at 2 cm intervals down to 20 cm, 4 cm below to bottom of core for sediment chlorophyll measurements, TOC and grain size determinations.

Sub-samples from the overlying water column were analyzed on board for dissolved oxygen, nutrients, denitrification, alkalinity, pH and total CO_2.

2.6 DMSP & PHYTOPLANKTON PIGMENTS

2.6.1 $DMSP_p$ Sampling

$DMSP_p$ samples (0.5-1 L) were collected from the surface to a maximum depth of 500 m, drawn from the Niskin bottles into amber high density polyethylene bottles using platinum-cure silicone tubing and filtered onto 25mm GF/F filters using low vacuum (< 5 psi) filtration. The filter was placed in an amber headspace vial with 3 mL HPLC-grade methanol and stored in the dark at 4°C until the samples could be analyzed. Upon analysis, the sample were based-hydrolyzed to convert the DMSP to DMS, which was measured using a cryogenic purge and trap system coupled to a Hewlett-Packard 5890 Series II gas chromatograph fitted with a flame photometric detector (DiTullio & Smith 1995).

2.6.2 Phytoplankton Pigments

Samples for taxon-specific pigments (0.75-2 L) were collected from the surface down to a maximum depth of 500 m, drawn from the Niskin bottles into amber high density polyethylene bottles using platinum-cure silicone tubing and filtered onto 25mm GF/F filters using low vacuum (< 5 psi) filtration. The filters were immediately frozen at -80°C until they could be analyzed by High Performance Liquid Chromatography (HPLC) in the lab. Separation of the pigments was carried out using reversed-phase, solvent-gradient chromatography on an automated Hewlett Packard 1050 HPLC system equipped with diode array and fluorescence detectors (DiTullio & Geesey 2002). The system was calibrated by repeated injections of pigment standards isolated from a variety of unialgal cultures maintained in the laboratory.

2.7 INSTRUMENTED MOORING

A subsurface oceanographic mooring was deployed in the benthic sampling regions southwest of St. Lawrence Island for NOAA/PMEL laboratory of Seattle Wa. (P. Stabeno, lead). The instrumentation consisted of 2 Seacats at 11 and 27m, one with fluorometer to assess plankton biomass from chlorophyll, 2 Microcats at 45 and 60m, 2 recording current meters at 14 and 55m, eight SBE39 temperature sensors at 17, 20, 23, 30, 35, 40, 50 and 65m, and an ISUS nitrate meter at 18m depth.

Mooring Station: 03STL-1A **July-2003**
Project: St. Lawrence Island Location: Bering Sea
Latitude: 62° 4.86' N Water depth: 82 meters
Longitude: 175° 0.06' W Currents (est.max): 70 cm/s

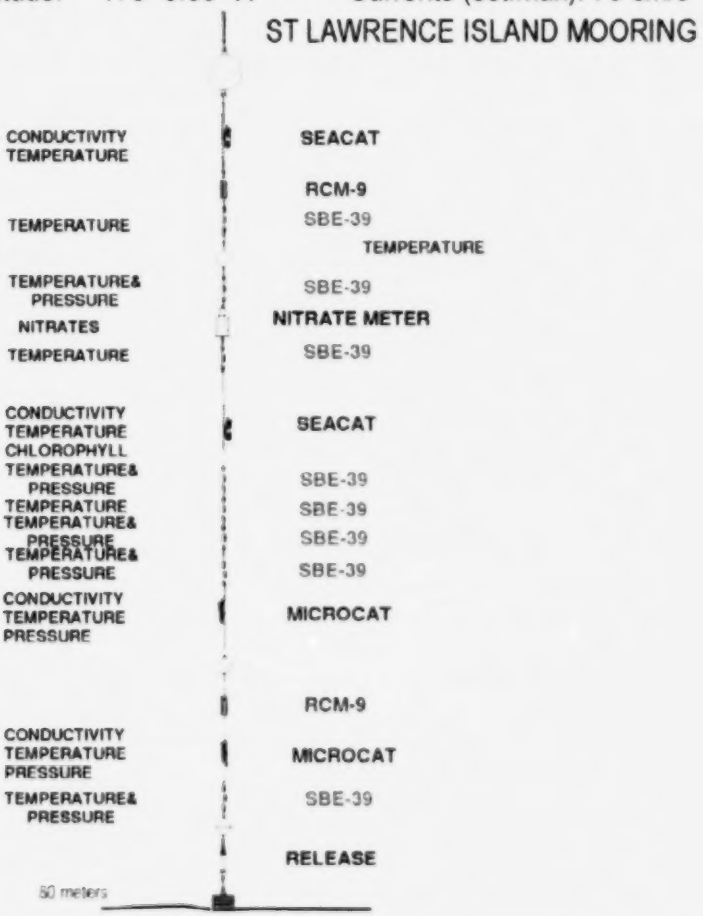

Figure 3. Diagram for St. Lawrence Island instrumented mooring.

2.8 DIOMEDE SITE SURVEY

A water property survey was conducted by boat around the location of the proposed outlet of a submerged seawater pipeline for the Bering Strait Ocean Observatory site on the western side of Little Diomede Island. Bottom and surface water samples were collected at all 13 stations (26 samples) for nutrients. Object was to distinguish quasi-permanent point sources of nutrients from temporal variability. At each station, salinity and temperature were measured using a YSI meter, and a UV meter was used to measure surface to bottom profiles of light and radiation field at the North line sites. Results of the survey were published by Cooper et al. (2006).

Table 3. Coordinates for site survey at Diomede Island.

		Decimal Minutes		Decimal Degrees	
Place	Alternate Name	Lat	Long	Lat	Long
North Perpendicular 0 (Beach)	North Beach	65°45.546'	168°57.101'	65.7591	-168.9517
North Perpendicular 1 (Pump Hole)	Pump	65°45.583'	168°57.239'	65.7597	-168.9540
Northern Lead Edge	Lead	65°47.182'	168°56.340'	65.7864	-168.9390
North Parallel A (northmost)	Grey	65°47.068'	168°56.440'	65.7845	-168.9407
North Parallel B	Orange	65°46.886'	168°56.512'	65.7814	-168.9419
South Perpendicular 0 (Beach)	South Beach	65°45.357'	168°57.069'	65.7560	-168.9512
South Perpendicular 1	Dud (no hole)	65°45.428'	168°57.122'	65.7571	-168.9520
South Perpendicular 2	Box	65°45.324'	168°57.398'	65.7554	-168.9566
South Perpendicular 3	Lake	65°45.296'	168°57.672'	65.7549	-168.9612
South Perpendicular 4	Two Stick	65°45.289'	168°57.931'	65.7548	-168.9655
South Perpendicular 5	2x4	65°45.261'	168°58.328'	65.7544	-168.9721
South Parallel A (northmost)	Baton Rouge	65°44.878'	168°59.044'	65.7480	-168.9841
South Parallel B	New Orleans	65°44.794'	168°59.112'	65.7466	-168.9852
International Date Line at Diomedes			168°58.370'		-168.9728
International Date Line North	IDLN	65°47.182'	168°58.370'	65.7864	-168.9728
International Date Line South	IDLS	65°44.794'	168°58.370'	65.7466	-168.9728

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APPENDIX 1. SCIENCE PARTICIPANTS

Participants On Board

Name	Affiliation	Position
Jane Eert	IOS	Chief Scientist
Jackie Grebmeier	UTK	Co-Chief Scientist
Lee Cooper	UTK	Benthic & water analysis
Peter Lee	CofC	DMSP sampling
Rebecca Pirtle-Levi	UTK	Sampling, Chlorophyll-a Analysis
Arianne Balsom	UTK	Sampling & analysis
Nathan Garcia	CofC	DMSP Sampling
Sarah Thornton	UTK	Oxygen Analysis
Sigrid Salo	PMEL/NOAA	Chlorophyll-a Analysis
David Brown	UTK	Sampling, outreach

Investigators and data analysts

Name	Affiliation	Program
Eddy Carmack	IOS	Program Co-Lead, physical oceanography
Fiona McLaughlin	IOS	Program Co-Lead, chemical oceanography
Bon van Hardenberg	IOS	CTD data & instrumentation
Jackie Grebmeier	UTK	Lead, benthic & water column
Lee Cooper	UTK	Benthic & water column
Jack DiTullio	CofC	Lead, DMSP and phytoplankton pigments
Germaine Gatien	IOS	Data processing
Liusen Xie	IOS	Data processing

Affiliation Abbreviation

IOS	Institute of Ocean Sciences, Sidney, BC
DFO	Department of Fisheries and Oceans, Canada
UTK	University of Tennessee at Knoxville
PMEL/NOAA	Pacific Meteorological & Environmental Laboratory, Seattle, WA.
CofC	College of Charleston, Charleston, South Carolina

APPENDIX 2. CTD INSTRUMENTATION SPECIFICATIONS

The primary CTD was a Sea-Bird Electronics SBE25 connected via a SBE32 water sampler pylon and 4000m conducting cable (on the Hawboldt CTD winch) to a SBE33 deck unit and data acquisition computer.

Primary CTD: SBE25 s/n 0293

Type	Make	S/N	Calibr. Date	Remarks
Pressure	SBE29	0464	27 Dec '02	max 1024m
Temperature	SBE 3	4115	31 Dec '02 & 15 May 04	
Conductivity	SBE 4	2607	31 Dec '02 & 14 May '04	
Oxygen	SBE 43	0052	06 Aug '01	Pumped
Transmissometer	SeaTech	139	23 Apr '01	Path length 0.25m
Fluorometer	Seapoint	2336	30X gain	not pumped
Bottom Contact	SBE		N/A	
Pump	SBE5	053100	N/A	
Water Sampler	SBE32	3215407-0172	N/A	Carousel 12-place
CTD Deck Unit	SBE33	3315407-0058	N/A	

The main CTD was mounted horizontal below the Carousel water sampler. The water intake at the temperature sensor was at the same height as the pressure sensor. The fluorometer, transmissometer and pumped dissolved oxygen sensors, were mounted on the side of the CTD housing.

The Carousel sample bottles are ~1.4m tall, and their center is ~1.0m above the CTD pressure sensor. A bottom contact switch provided an on-screen warning (plot line) when the weight on the line below it touched bottom.

Backup CTD: SBE19 s/n 2668

As back-up system, a SBE 19 was brought along, and several inter-comparison casts were down. Sensors calibrations for this CTD before the cruise were done on 20 Feb 2002, after the cruise on 15 Dec 2004.

Table 3. Notes on casts from logbook.

Cast	Comments
1	Bottle 10 was swapped out before the cast and replaced with a 5L bottle. The nylon locking shaft had broken. The replacement bottle leaked slightly.
2	air valve was left open, so no salinity calibration sample taken.
3	Bottle 10 repaired and returned - no bottle integrity problems.
5	Extra bottle taken at bottom of cast (bottle 2) for seawater collection for the lab.
9	CTD touched bottom at 78 db in 82m of water
15	Surface bottle taken on short extra cast 15a
18	Bottle 3 did not fire. Checked out on deck - fired OK
22	Bottle 11 leaked slightly
23	Bottom contact switch installed, DO sensor did not work
25	Casts before this had 2001 calibration values for T,P and C - this one and after have the latest calibrations.
27	Bottle 11 leaked badly - reseated O-ring
31	Salinity calibration sample at 28m - no rosette sheet
32	Salinity calibration sample at 41m - no rosette sheet
33	Duplicate salinity calibration sample at 41m - no rosette sheet

APPENDIX 4. CTD PROCESSING NOTES

The Seabird Data Processing programs were used with the instrument configuration file to

- convert the HEX data to physical units, and
- generate the files of raw CTD values at each depth where a rosette bottle was tripped.
- filter pressure, temperature and conductivity,
- compensate for the thermal mass of the conductivity cell.

Following that, the IOS-shell suite of data processing modules was used to produce final calibrated edited CTD profiles. The headers of the processed data files include a description of each step with the parameters used:

- relative to pressure, the conductivity was shifted by 1 sec,
- a boxcar filter of width 5 was applied to the resulting salinity data.
- surface records from beside the ship were deleted, and
- the conductivity and dissolved oxygen records removed from the files.
- salinities were edited to remove poor data and
- final data were bin-averaged to 0.25 m to show detail in shallow casts.

APPENDIX 5. LOCATION OF SCIENCE STATIONS

The table below lists station names, dates and locations of CTD/Rosette casts with water depth, cast depth and the water sample consecutive numbers.

Table 4. CTD/Rosette Casts

Nr	Station Name	Start Date & Time (UTC)	Lat (°N)	Lat Min	Lon (°W)	Lon Min	Water Depth (m)	Cast Depth (db)	Sample nrs
1	BS-1	2003/07/13 01:46	56	18.66	172	49.11	1642	1000	1 to 12
2	BS-2	2003/07/13 03:28	56	25.05	172	47.58	1583	1000	13
3	BS-3	2003/07/13 04:30	56	28.49	172	46.76	740	700	14 to 25
4	BS-4	2003/07/13 05:55	56	32.64	172	45.36	245	237	26 to 36
5	BS-5	2003/07/13 06:50	56	38.65	172	43.98	134	128	
6	BS-6	2003/07/13 23:03	59	19.11	172	29.97	109	103	37 to 48
7	SLIP1	2003/07/14 16:04	62	0.74	175	3.32	84	78	49 to 59
8	SLIP2	2003/07/14 19:19	62	2.97	175	12.08	84	78	60 to 72
9	NBS	2003/07/14 22:26	62	4.81	174	59.6	78	78	73 to 76
10	SLIP3	2003/07/15 00:53	62	23.37	174	34.28	72	69	77 to 88
11	SLIP5	2003/07/15 05:13	62	33.25	173	33.75	67	64	89 to 100
12	SLIP4	2003/07/15 09:16	63	1.7	173	27.33	73	68	101 to 112
13	BCS6	2003/07/15 16:57	63	50.86	172	24.14	56	52	113 to 123
14	UT-BS5	2003/07/16 01:30	64	39.97	169	55.28	47	44	124 to 135
15	UT-BS2	2003/07/16 04:47	64	40.92	169	5.94	46	42	136 to 146
16	UT-BS4	2003/07/16 08:46	64	57.52	169	52.9	50	47	147 to 158
17	UT-BS1	2003/07/16 13:08	64	59.57	168	8.22	50	45	159 to 170
18	BRS1	2003/07/16 19:08	65	39.04	168	13.01	40	36	171 to 179
19	BRS2	2003/07/16 20:09	65	40.03	168	23.91	52	45	180 to 189
20	BRS3	2003/07/16 21:21	65	40.85	168	33.97	52	48	190 to 200
21	BRS4	2003/07/16 22:34	65	41.95	168	42.87	52	48	201 to 211
22	BRS5	2003/07/16 23:47	65	42.96	168	53.84	50	45	212 to 222
23	UTN-1	2003/07/18 03:55	66	42.47	168	23.97	34	29	223 to 231
24	UTN-2	2003/07/18 12:14	66	3.09	168	44.08	45	39	232 to 242
25	UTN-3	2003/07/18 14:10	67	19.85	168	59.77	50	45	243 to 254
26	UTN-4	2003/07/18 16:14	67	30.13	168	54.75	50	45	255 to 266
27	UTN-5	2003/07/18 18:16	67	40.21	168	57.41	50	45	267 to 278
28	UTN-6	2003/07/18 21:22	67	44.24	168	26.64	49	45	279 to 290
29	UTN-7	2003/07/19 00:11	67	59.87	168	55.19	57	53	291 to 302
30	BD-6	2003/07/19 09:50	69	11.75	166	8.81	30	27	303 to 308
31	CKS-1	2003/07/19 23:19	70	37.03	161	5.78	34	28	309
32	BD-7	2003/07/20 04:44	71	9.26	158	24.26	46	43	310
33	BD-8	2003/07/20 07:21	71	17.94	157	0.06	47	43	311

APPENDIX 6. INDIVIDUAL STATION DATA PLOTS

The following pages contain the data plots for each CTD cast taken on the 200318 cruise. These consist of CTD & chemistry profiles and T/S plots.

CTD parameters shown are:

- theta (potential temperature),
- salinity,
- fluorescence and
- transmissivity

Water sample chemistry parameters shown are:

- salinity,
- silicate,
- orthophosphate,
- nitrate + nitrite,
- chlorophyll-a and
- ^{18}O (at Bering Strait section only)

Other tracers collected but not included in this report are:

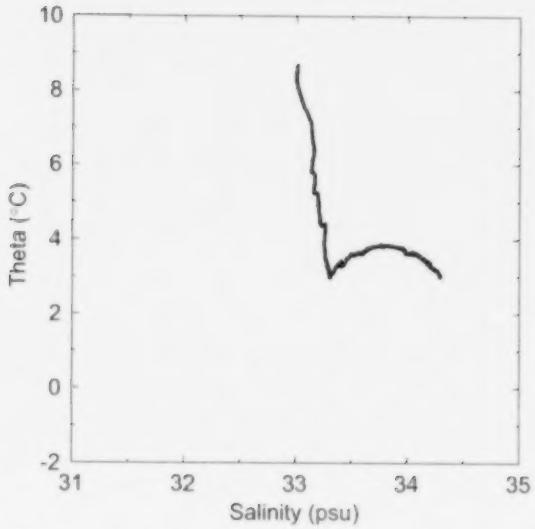
- barium,
- DMSPn and
- phaeo-pigments.

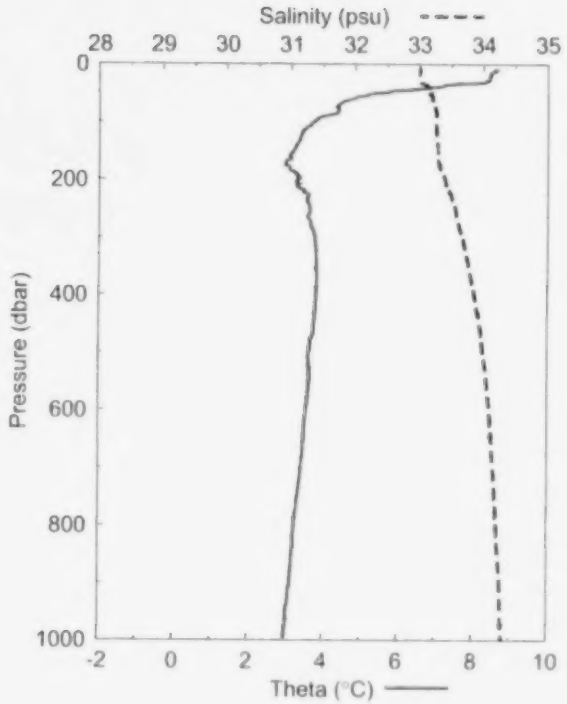
Cruise: 2003-18

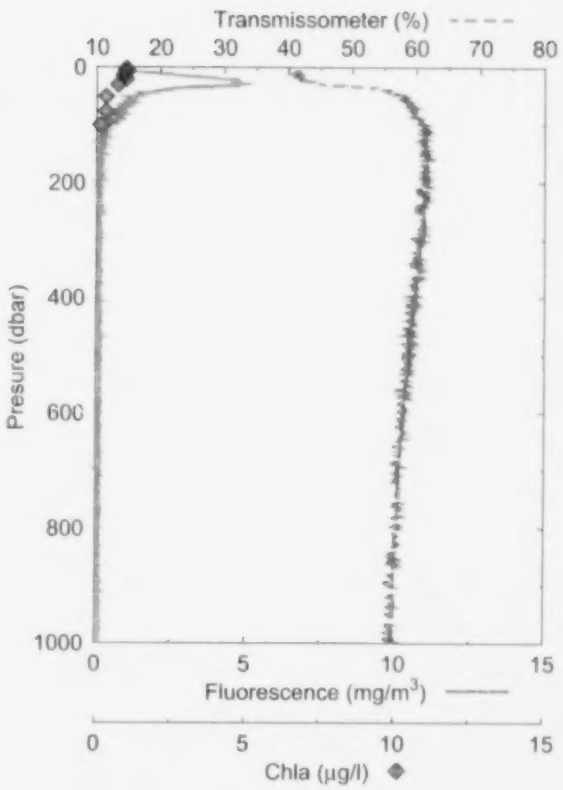
Cast: 1, Station: BS-1

Date/Time: Jul 13 2003 01:44UTC

Position: 56° 18.55'N, 172° 48.83'W





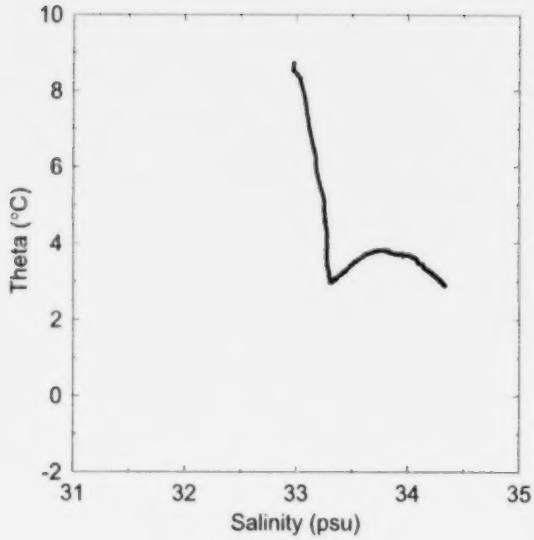


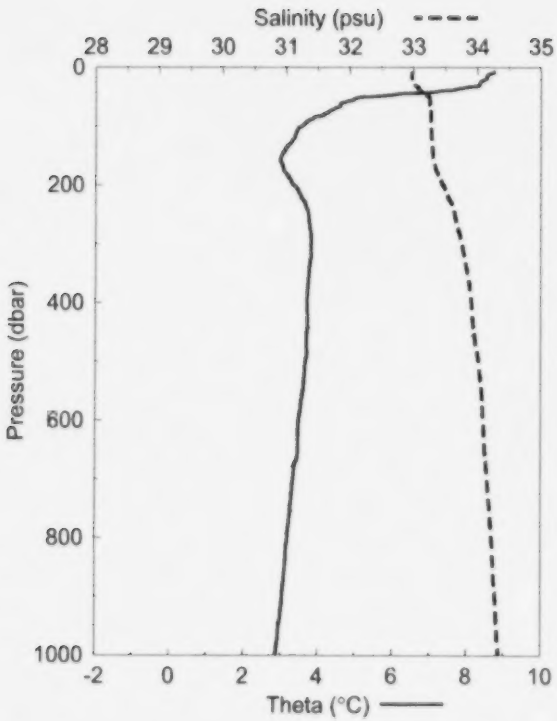
Cruise: 2003-18

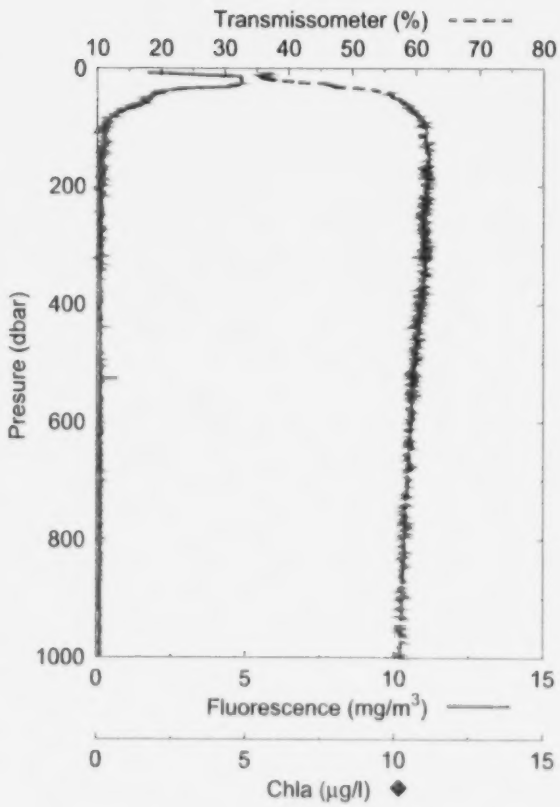
Cast: 2, Station: BS-2

Date/Time: Jul 13 2003 03:27UTC

Position: 56 ° 25.05'N, 172° 47.58'W





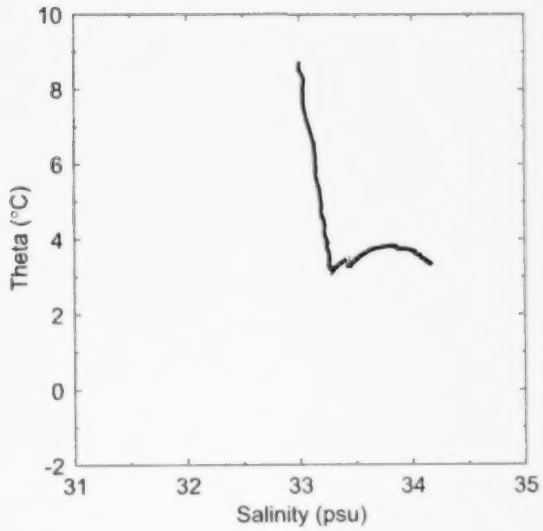


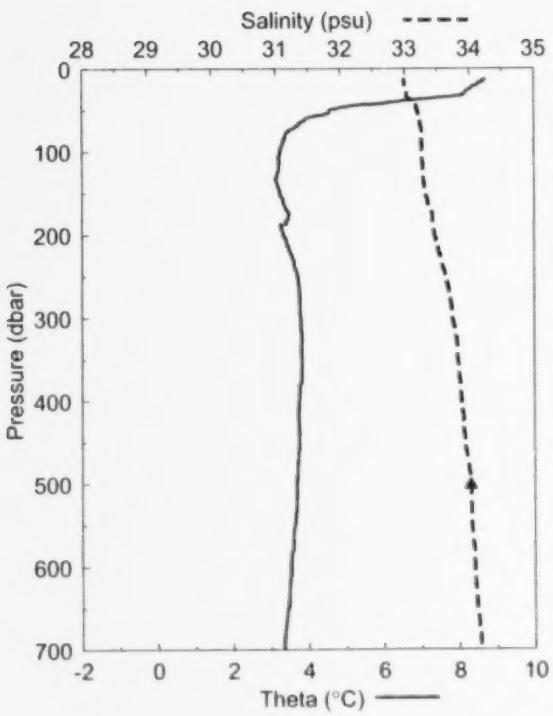
Cruise: 2003-18

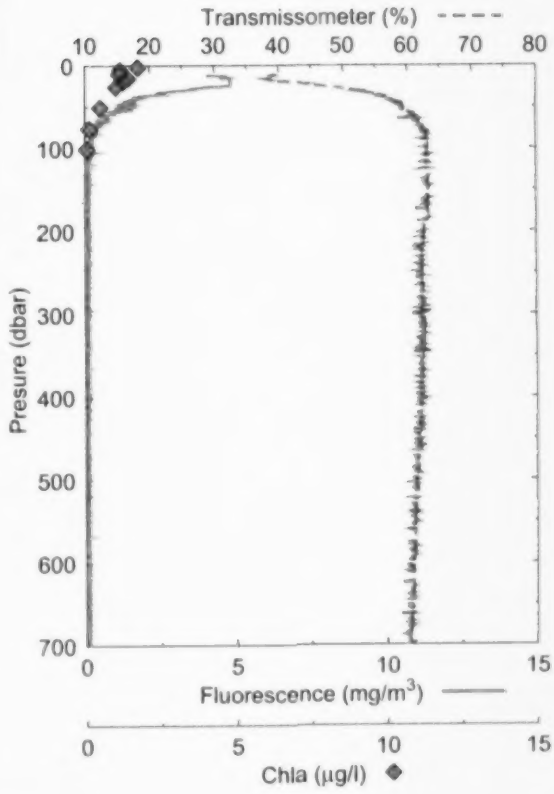
Cast: 3, Station: BS-3

Date/Time: Jul 13 2003 04:29UTC

Position: 56° 28.48'N, 172° 46.76'W





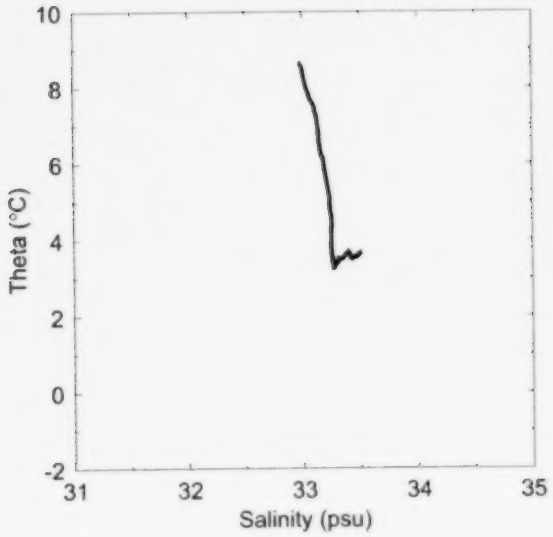


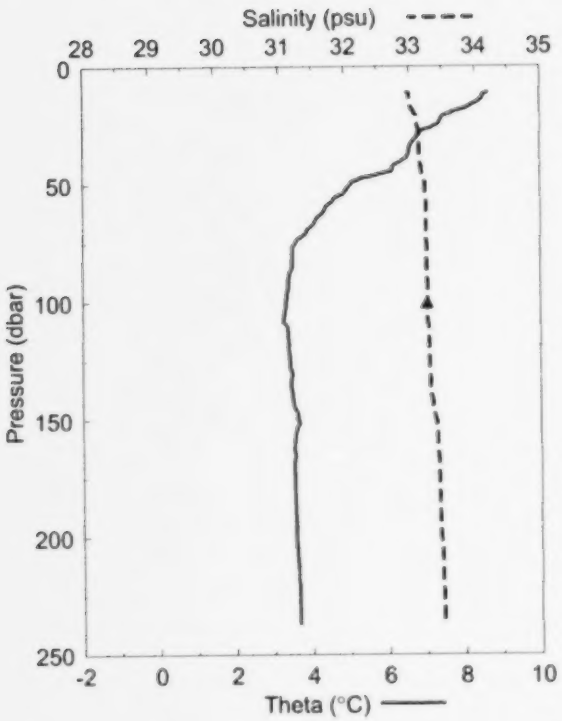
Cruise: 2003-18

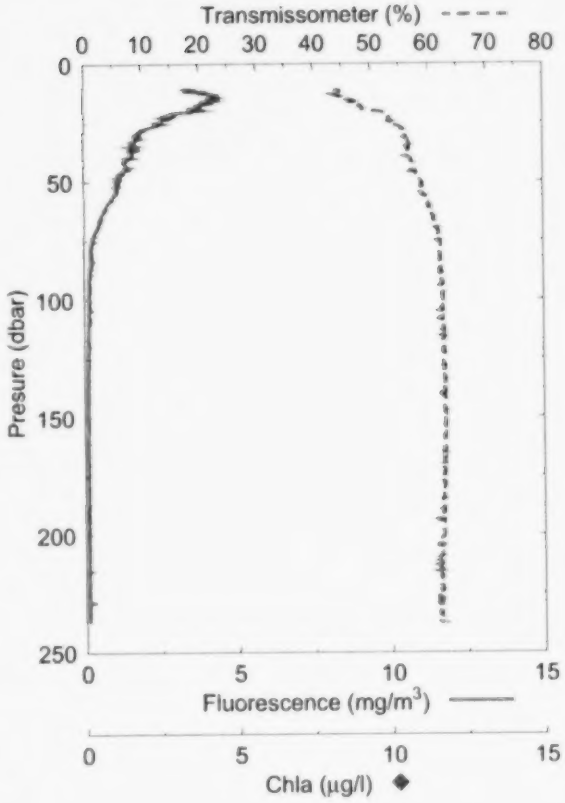
Cast: 4, Station: BS-4

Date/Time: Jul 13 2003 05:55 UTC

Position: 56° 32.63'N, 172° 45.36'W





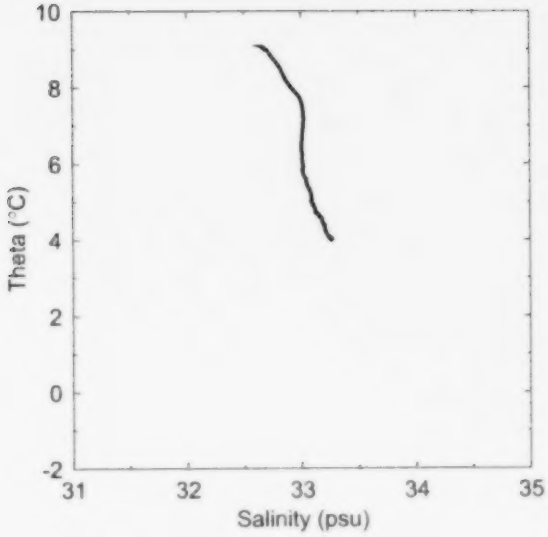


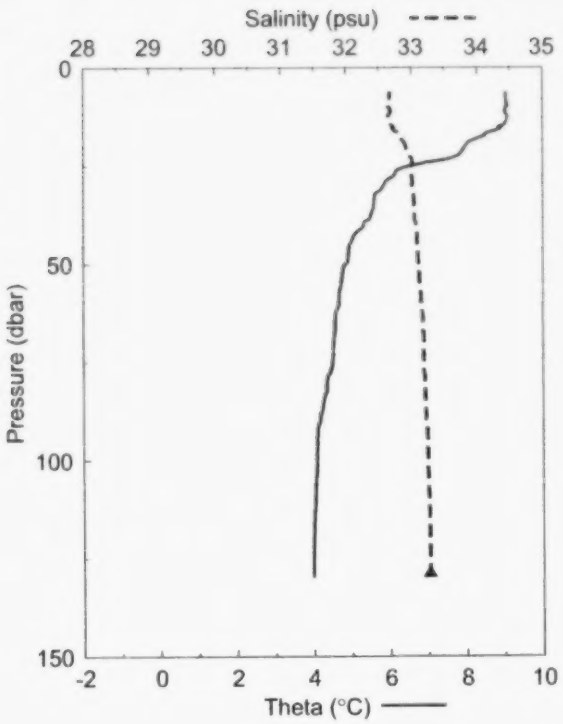
Cruise: 2003-18

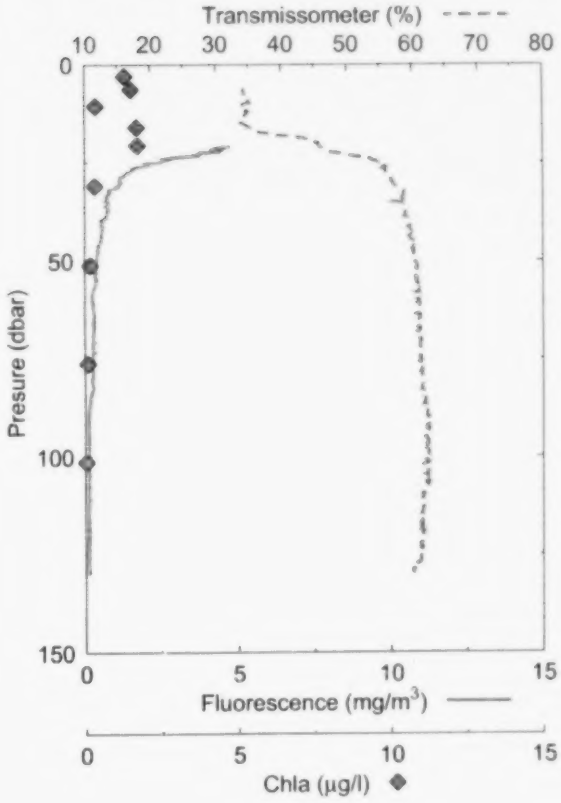
Cast: 5, Station: BS-5

Date/Time: Jul 13 2003 06:50UTC

Position: 56° 38.65'N, 172° 43.98'W





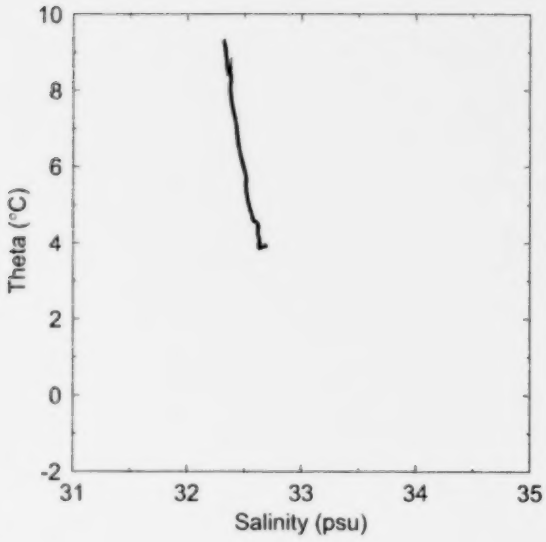


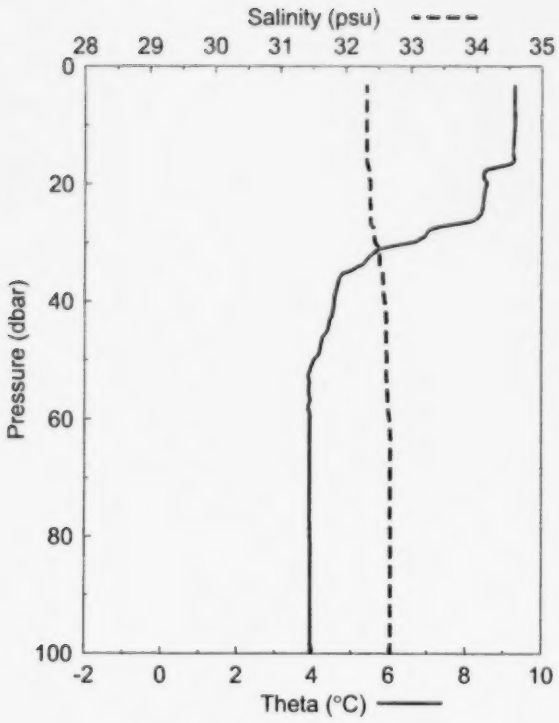
Cruise: 2003-18

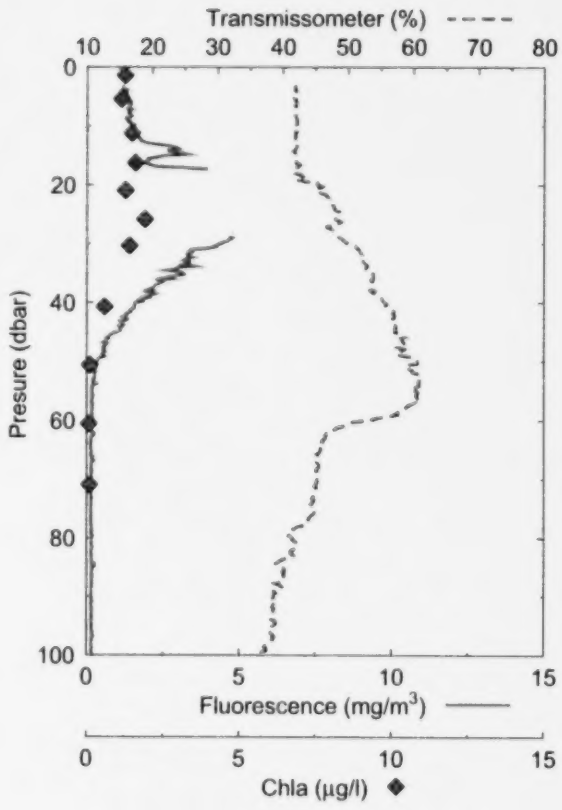
Cast: 6, Station: BS-6

Date/Time: Jul 13 2003 23:03 UTC

Position: 59° 19.06'N, 173° 29.93'W





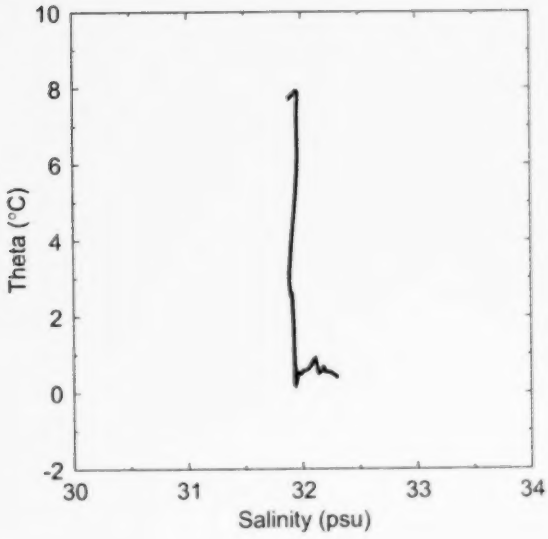


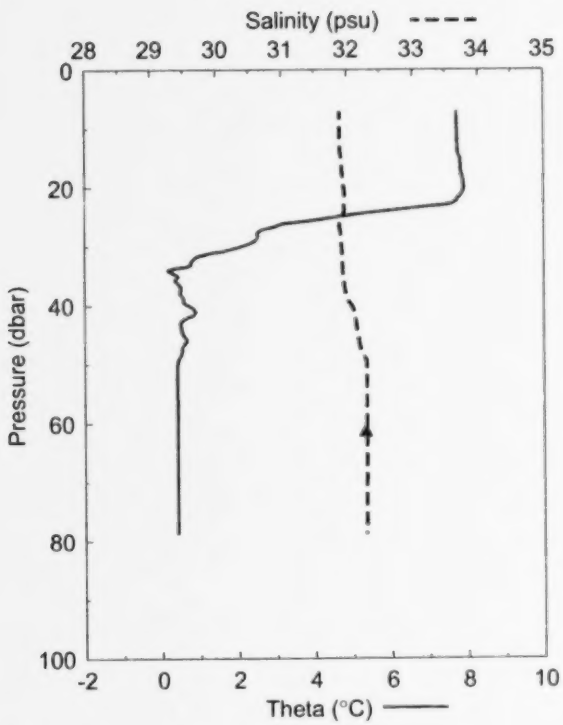
Cruise: 2003-18

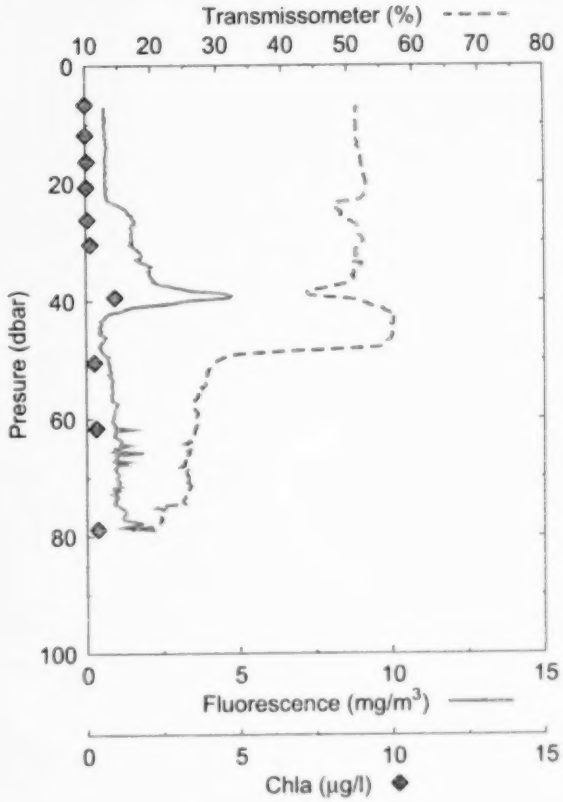
Cast: 7, Station: SLIP1

Date/Time: Jul 14 2003 16:03UTC

Position: 62° 0.74'N, 175° 3.32'W





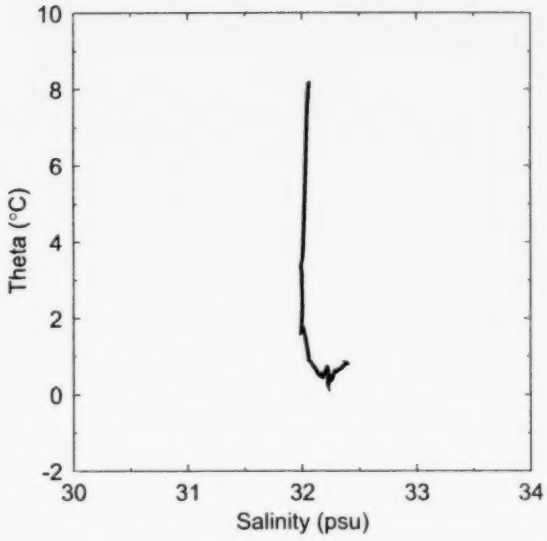


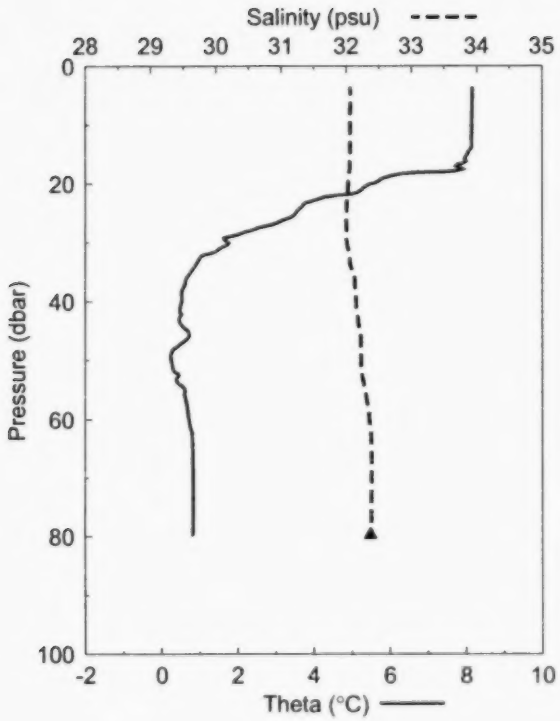
Cruise: 2003-18

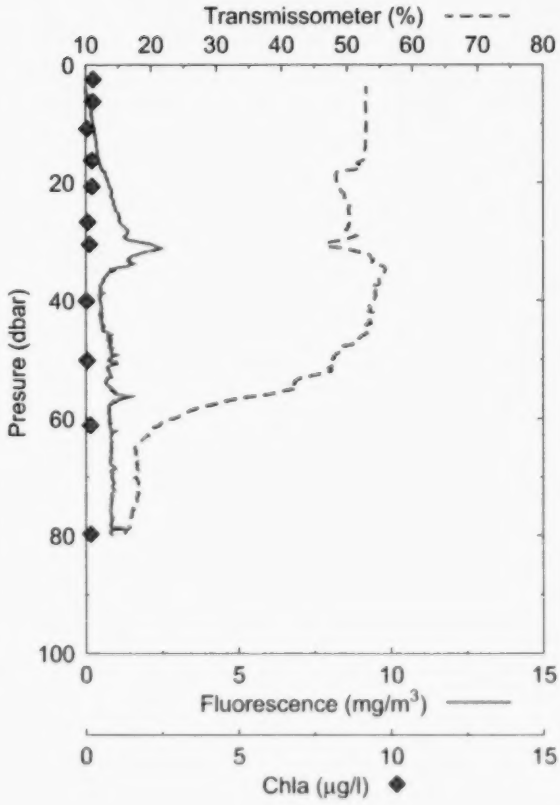
Cast: 8, Station: SLIP2

Date/Time: Jul 14 2003 19:18UTC

Position: 62° 3.03'N, 175° 12.32'W





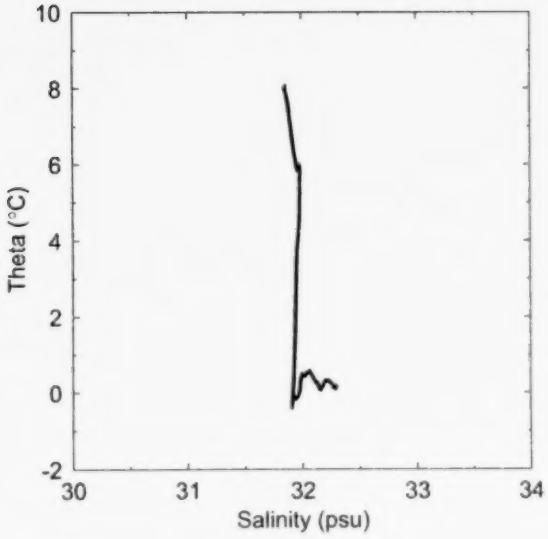


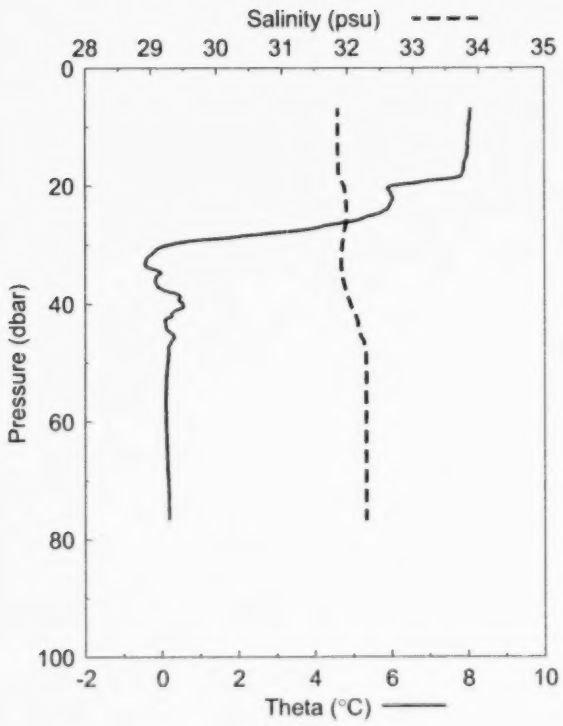
Cruise: 2003-18

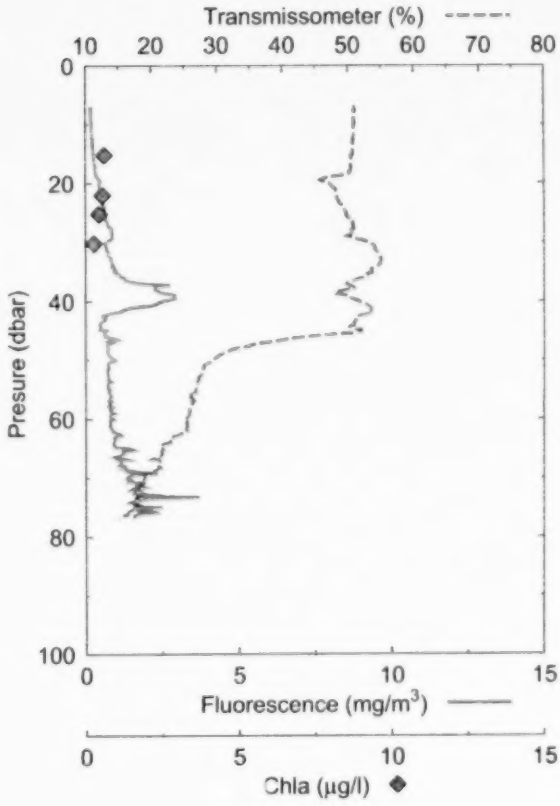
Cast: 9, Station: NBS MOORING

Date/Time: Jul 14 2003 22:25UTC

Position: 62° 4.81'N, 174 ° 59.62'W





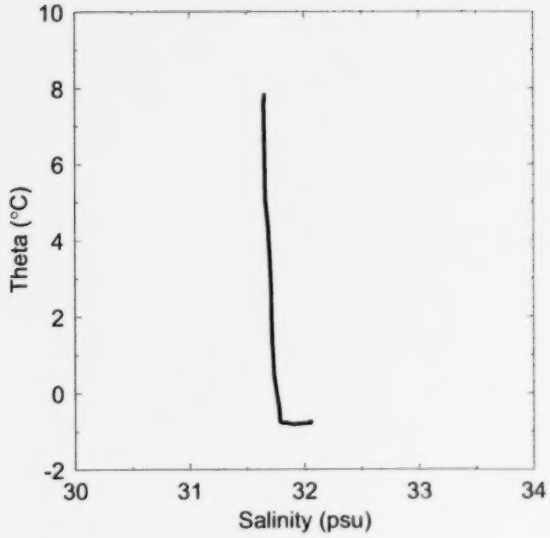


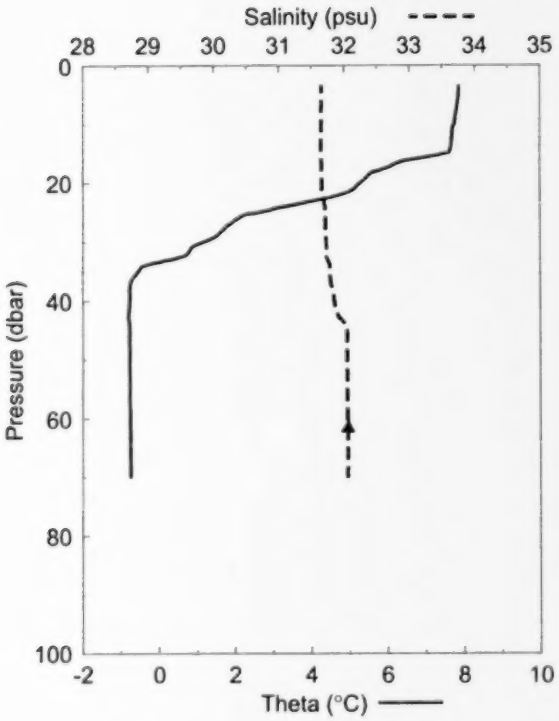
Cruise: 2003-18

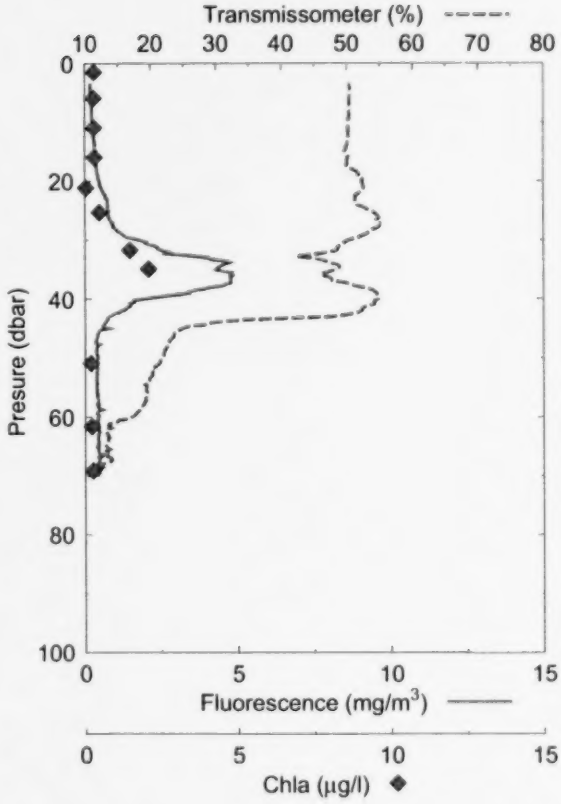
Cast: 10, Station: SLIP3

Date/Time: Jul 15 2003 00:52UTC

Position: 62° 23.57'N, 174° 34.06'W





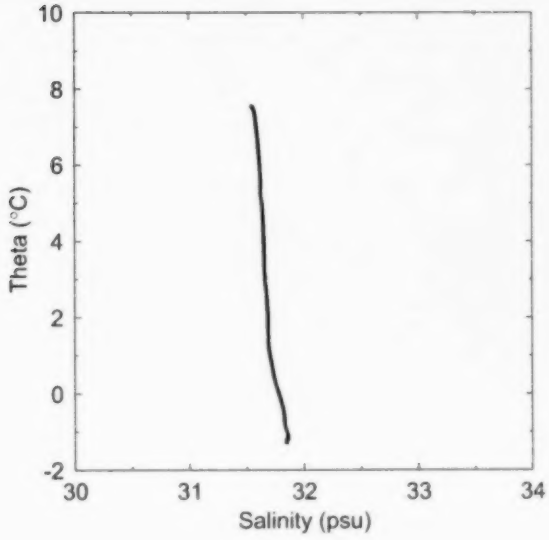


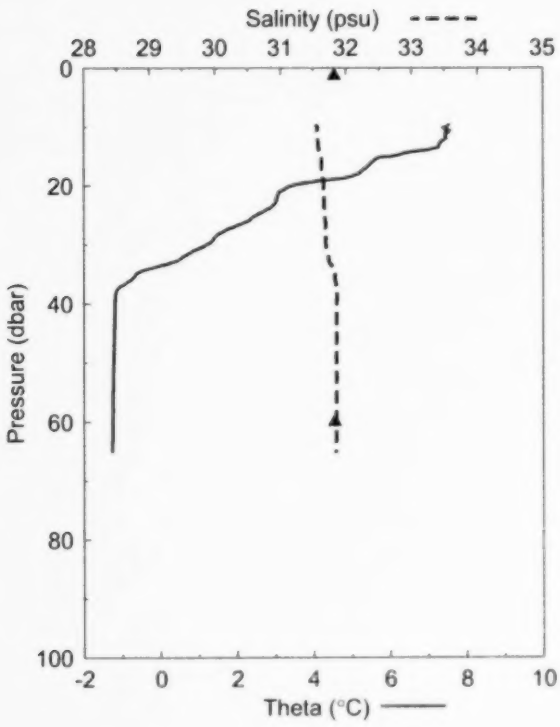
Cruise: 2003-18

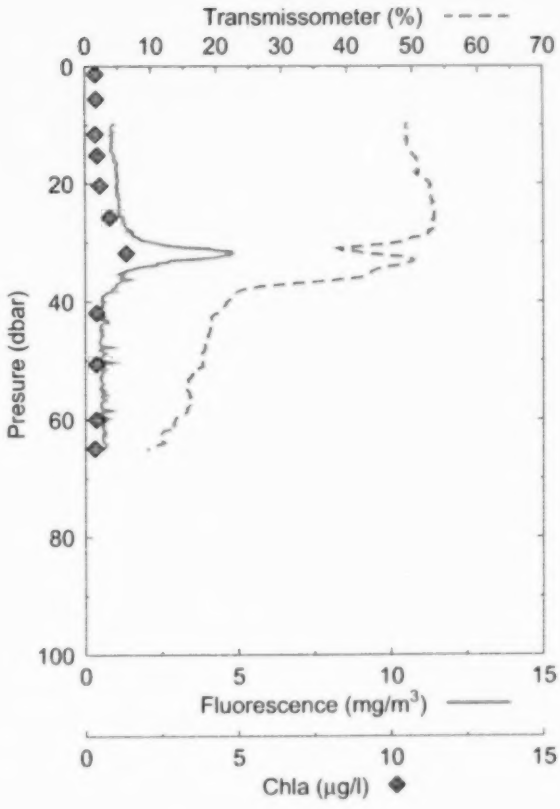
Cast: 11, Station: SLIP5

Date/Time: Jul 15 2003 05:13UTC

Position: 62° 33.75'N, 173° 33.25'W





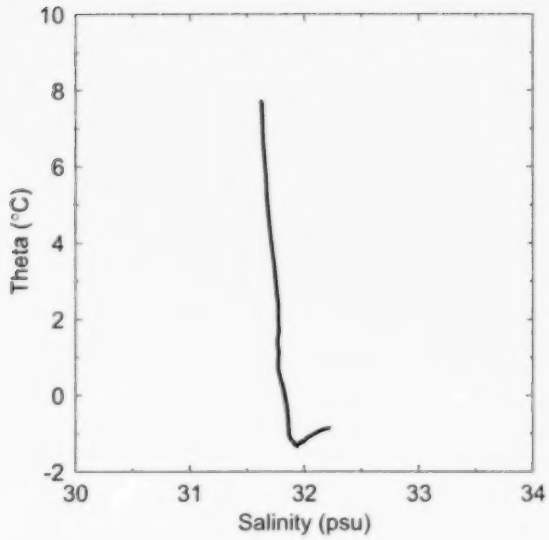


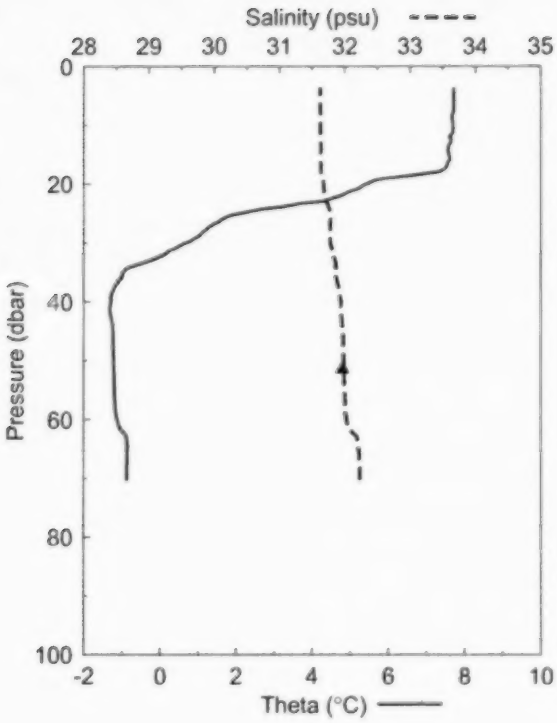
Cruise: 2003-18

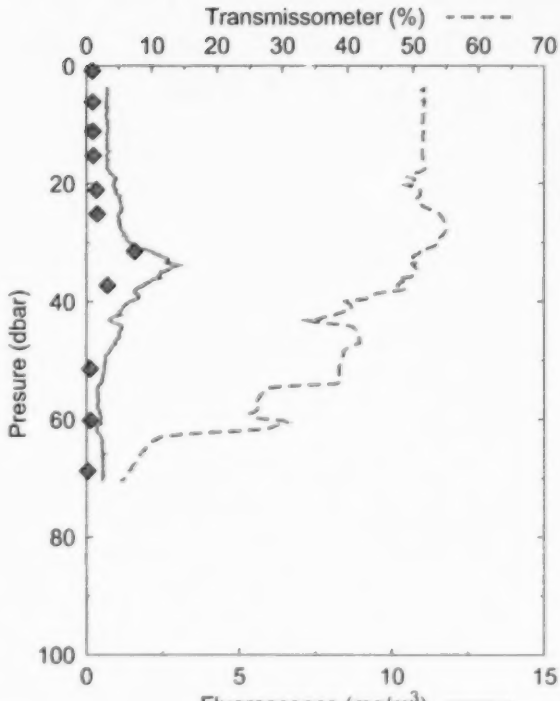
Cast: 12, Station: SLIP4

Date/Time: Jul 15 2003 09:16UTC

Position: 63° 1.70'N, 173° 27.33'W





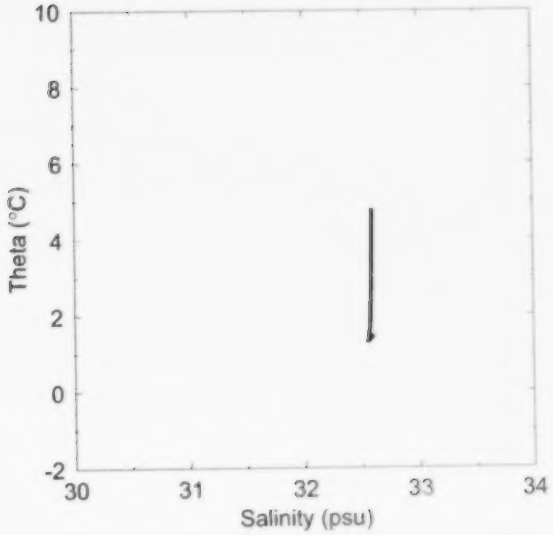


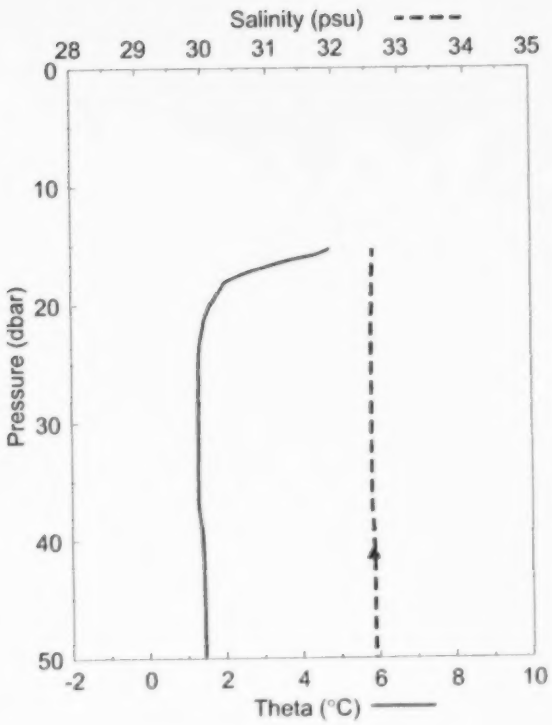
Cruise: 2003-18

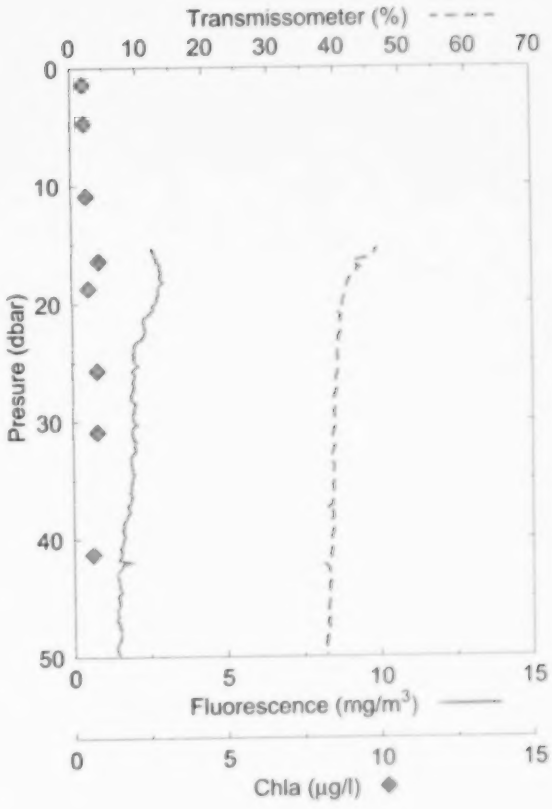
Cast: 13, Station: BCS6

Date/Time: Jul 15 2003 16:57UTC

Position: 63° 50.86'N, 172° 24.14'W





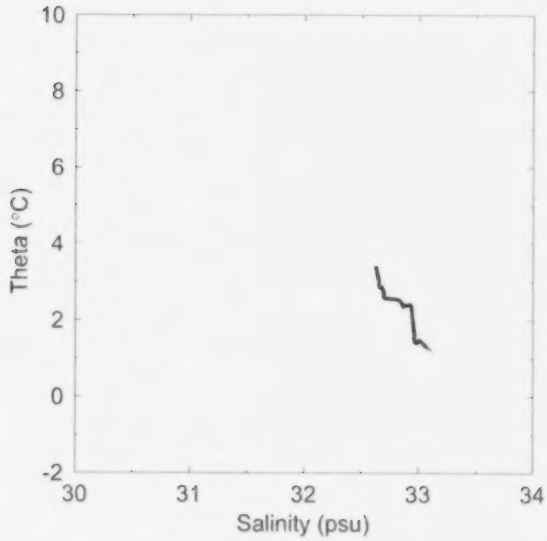


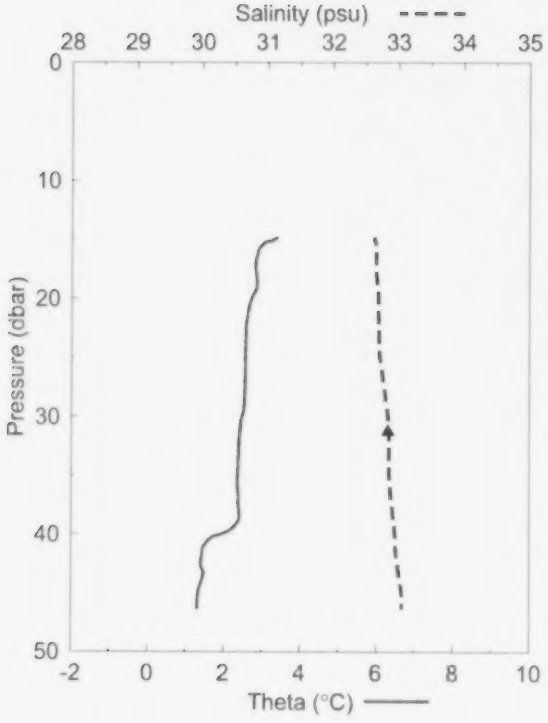
Cruise: 2003-18

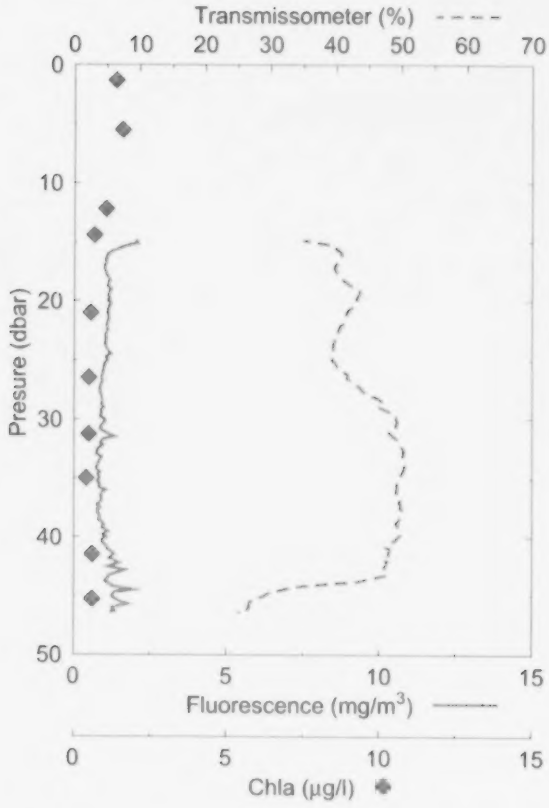
Cast: 14, Station: UT-BS5

Date/Time: Jul 16 2003 01:30UTC

Position: 64° 39.95'N, 169° 55.27'W





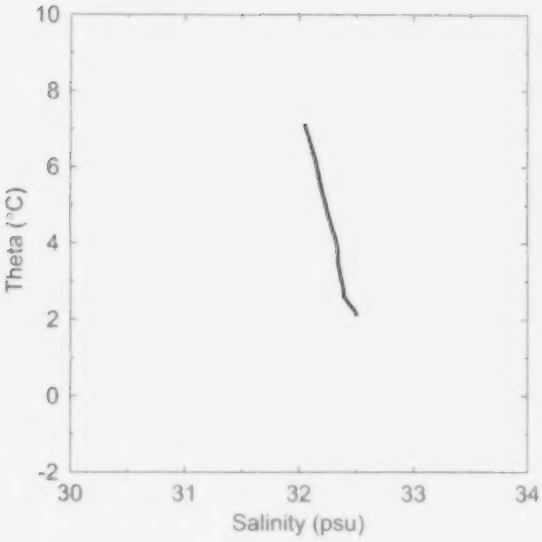


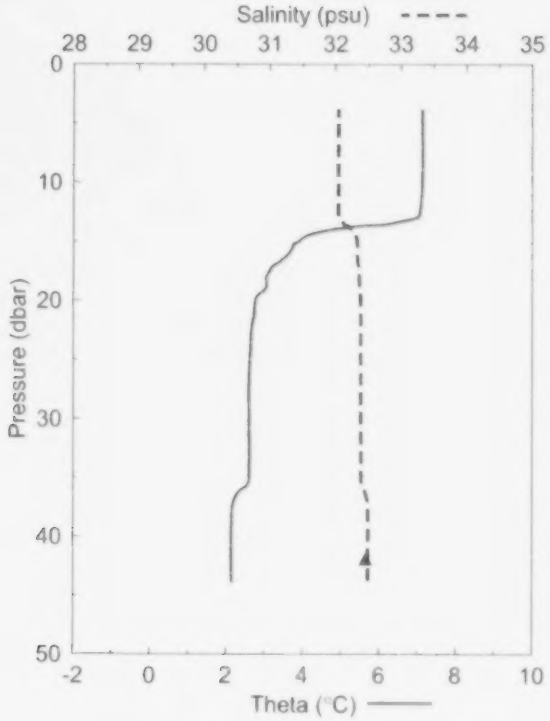
Cruise: 2003-18

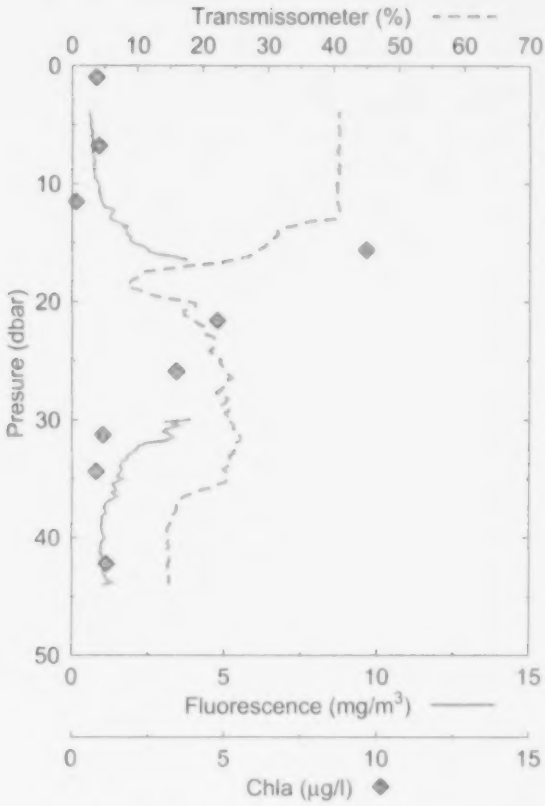
Cast: 15, Station: UT-BS2

Date/Time: Jul 16 2003 04:47UTC

Position: 64° 40.92'N, 169° 5.94'W





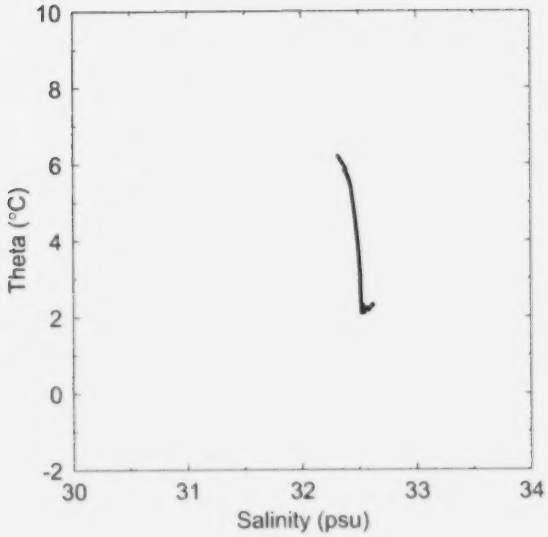


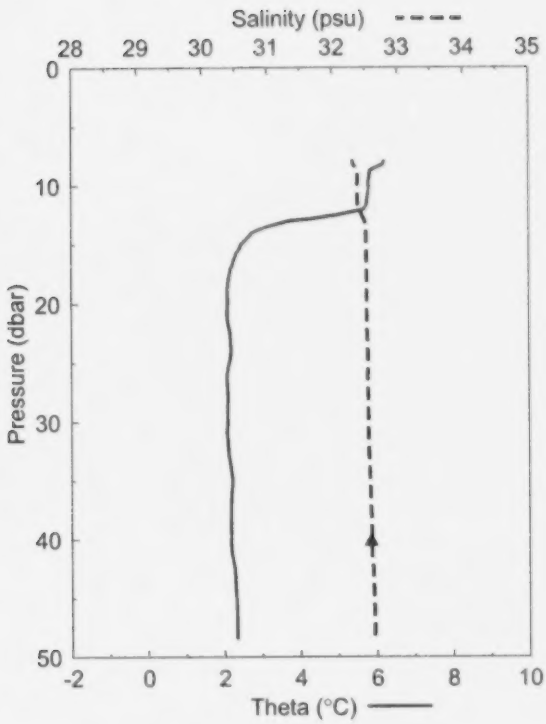
Cruise: 2003-18

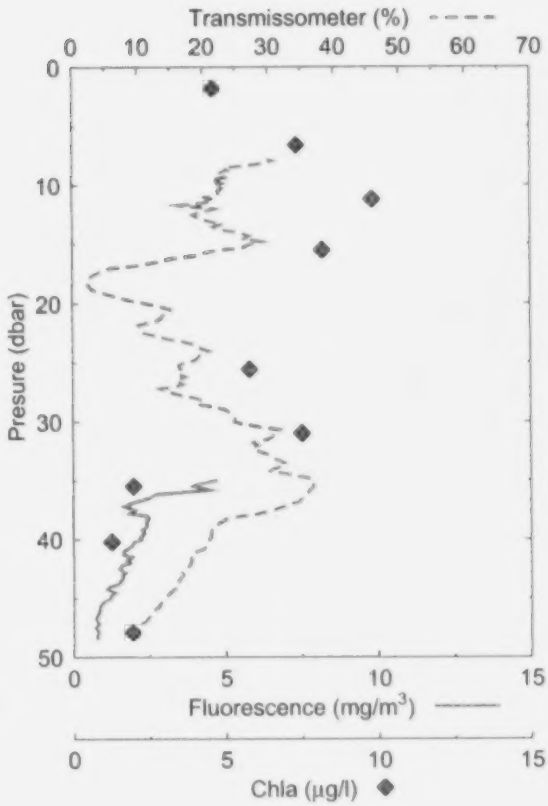
Cast: 16, Station: UT-BS4

Date/Time: Jul 16 2003 08:46UTC

Position: 64° 57.51'N, 169° 52.87'W





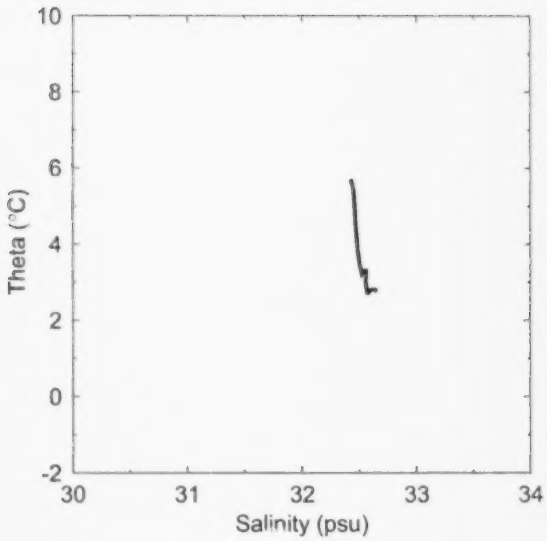


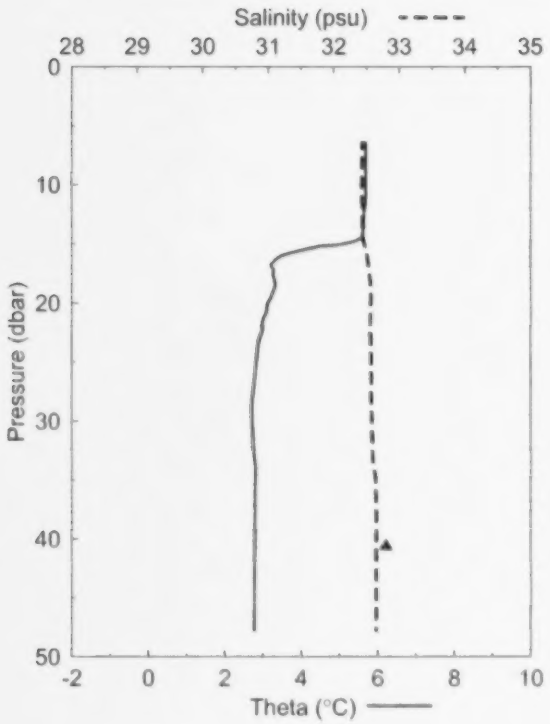
Cruise: 2003-18

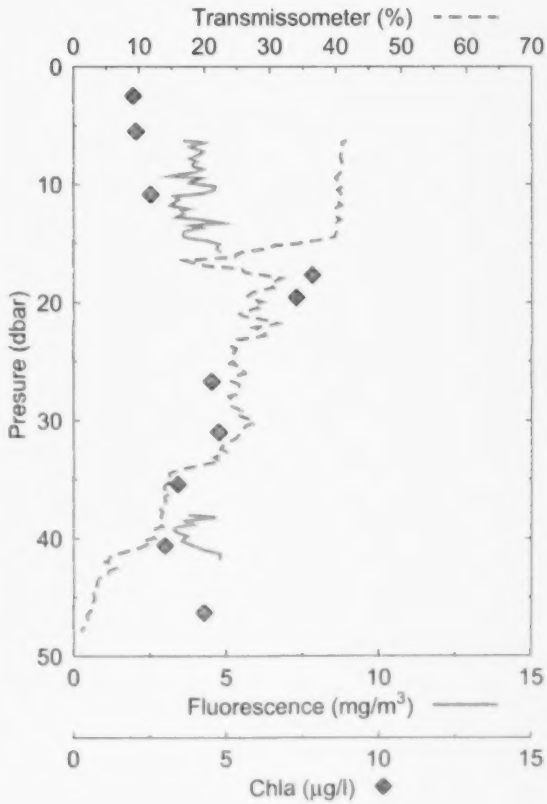
Cast: 17, Station: UT-BS1

Date/Time: Jul 16 2003 12:07UTC

Position: 64° 59.56'N, 169° 8.45'W





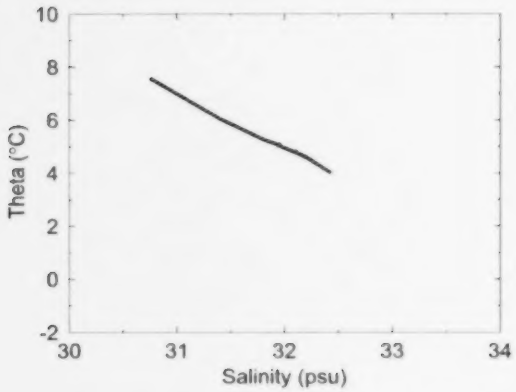


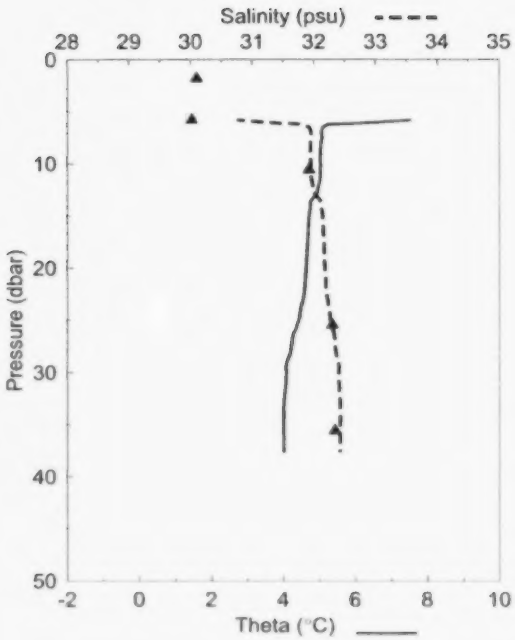
Cruise: 2003-18

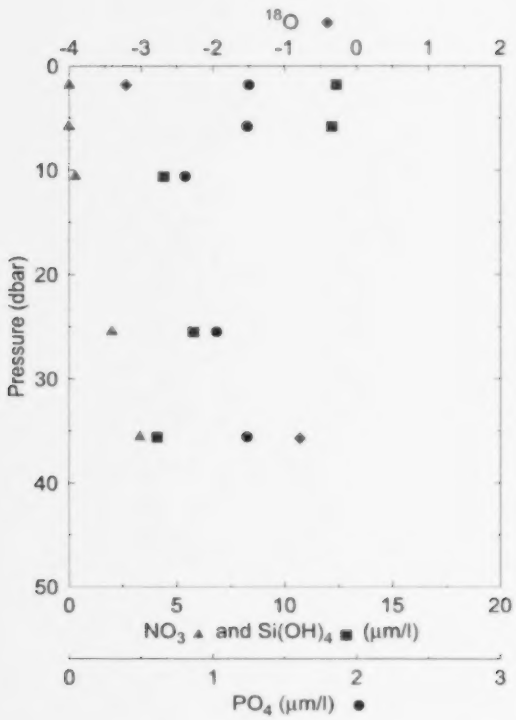
Cast: 18, Station: BRS1

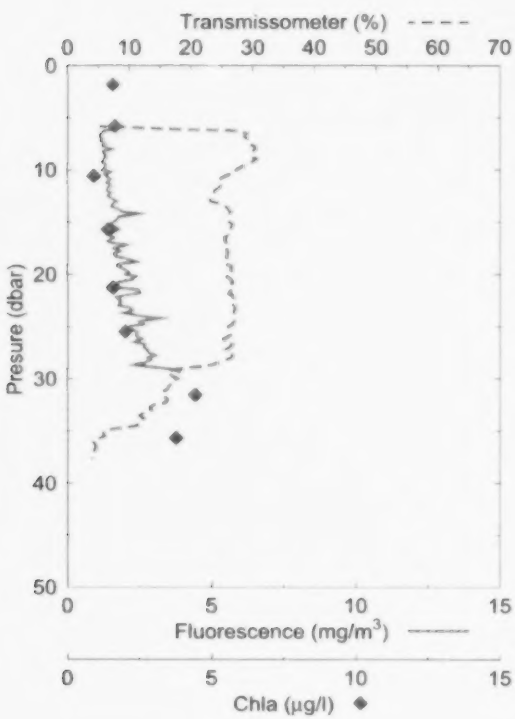
Date/Time: Jul 16 2003 19:08UTC

Position: 65° 39.02'N,168° 13.00'W







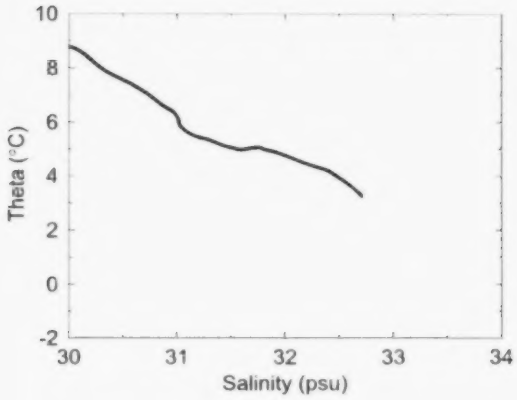


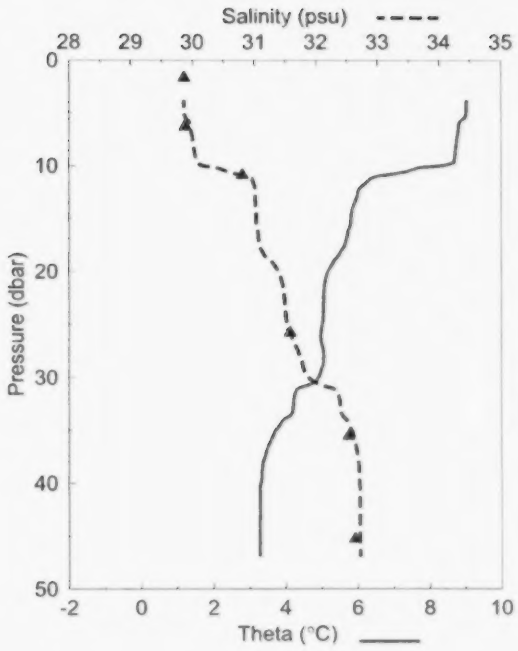
Cruise: 2003-18

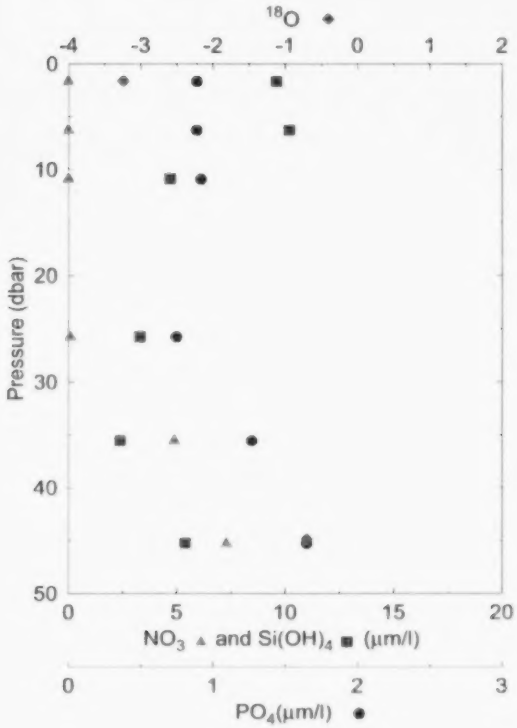
Cast: 19, Station: BRS2

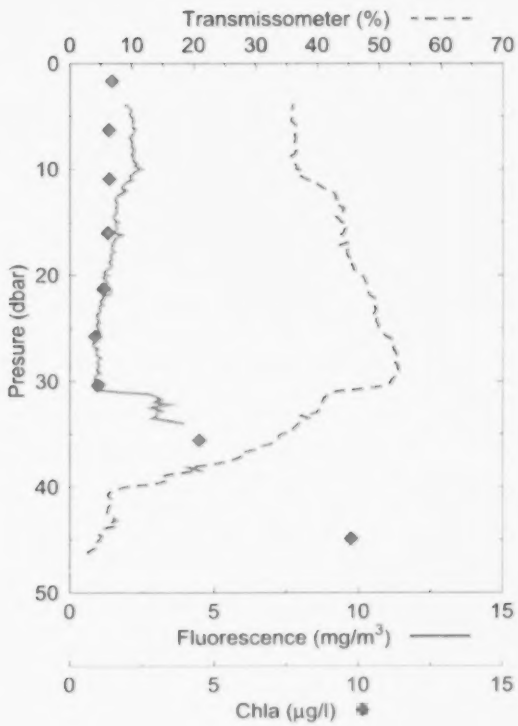
Date/Time: Jul 16 2003 20:09UTC

Position: 65° 40.03'N, 168° 23.90'W







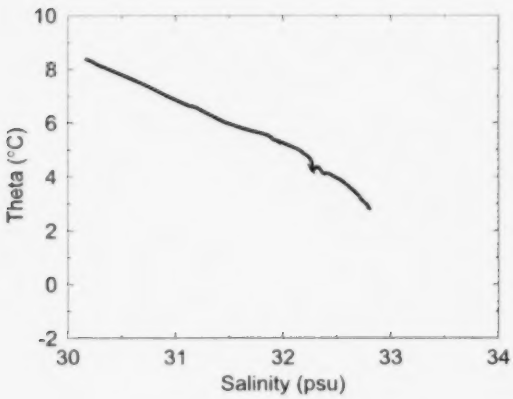


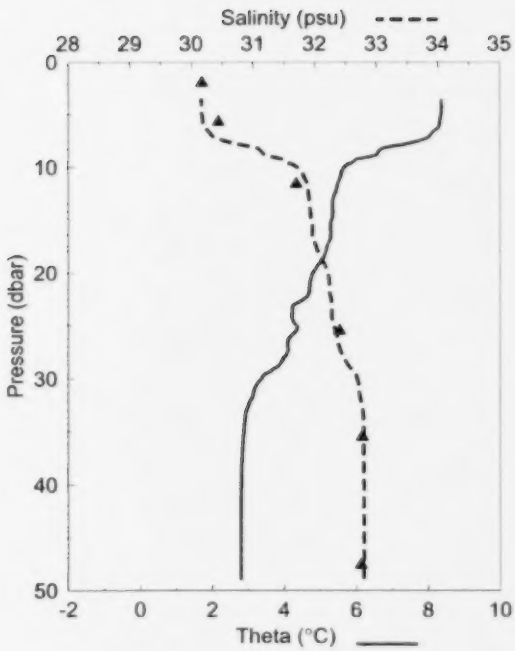
Cruise: 2003-18

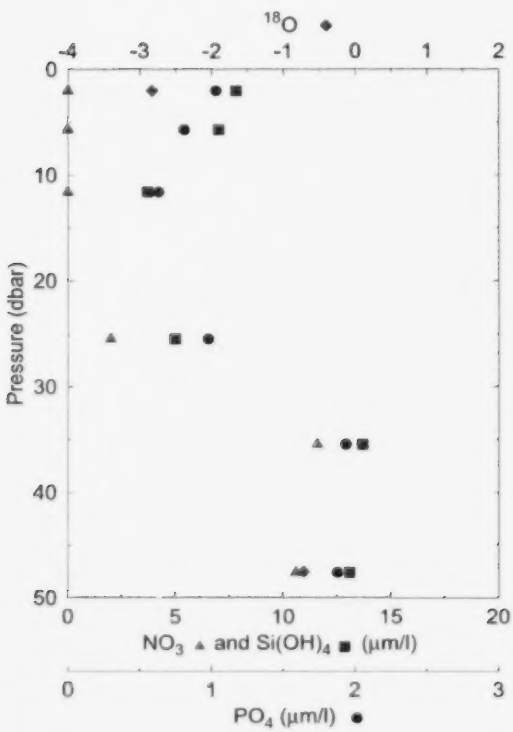
Cast: 20, Station: BRS3

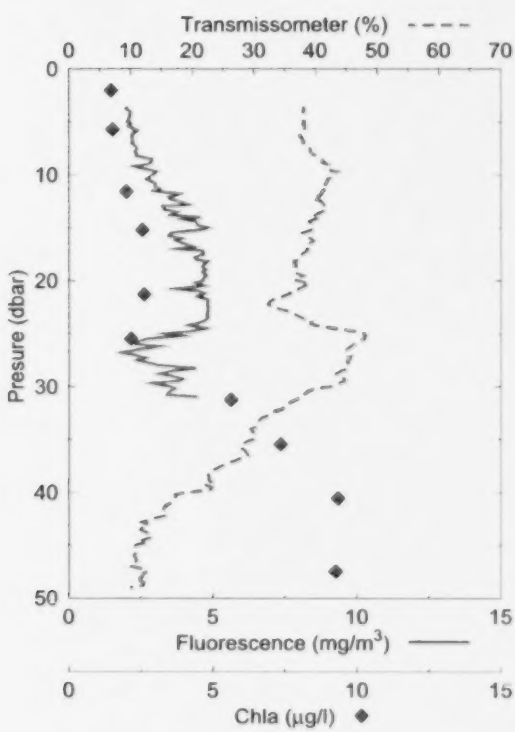
Date/Time: Jul 16 2003 21:21UTC

Position: 65° 40.86'N, 168° 33.97'W







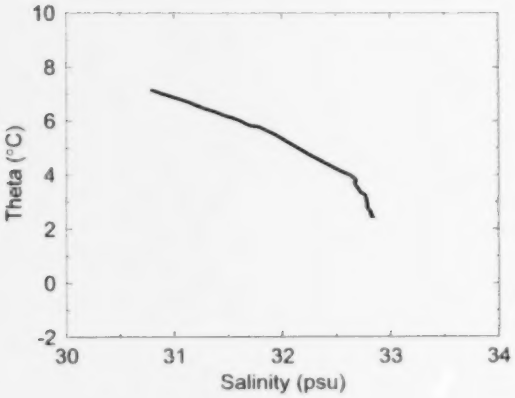


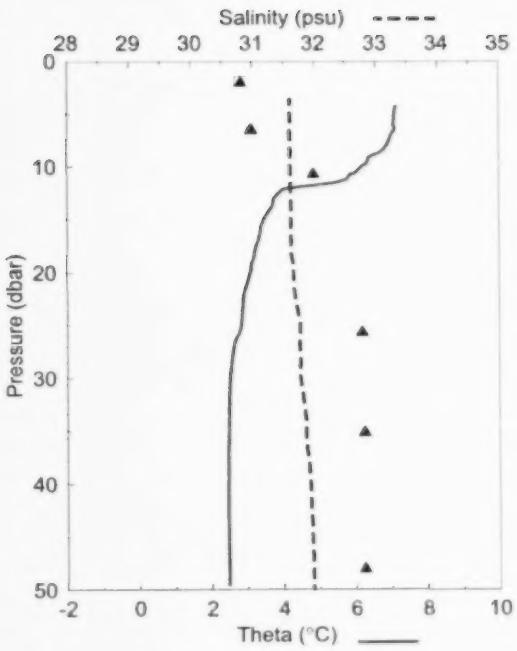
Cruise: 2003-18

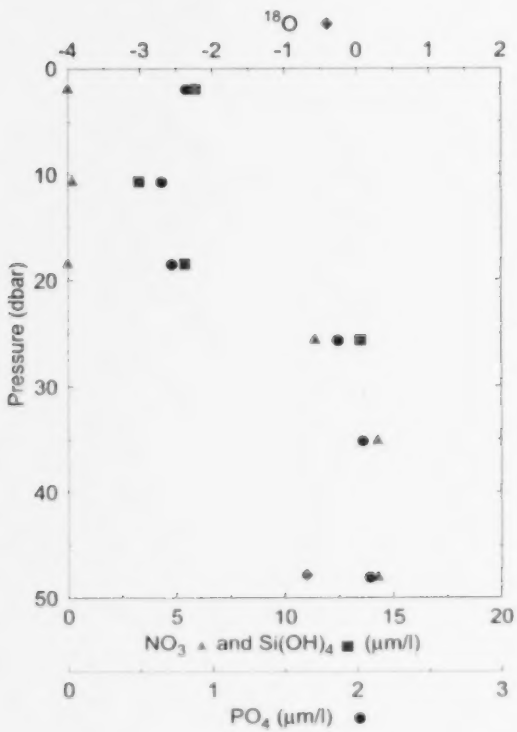
Cast: 21, Station: BRS4

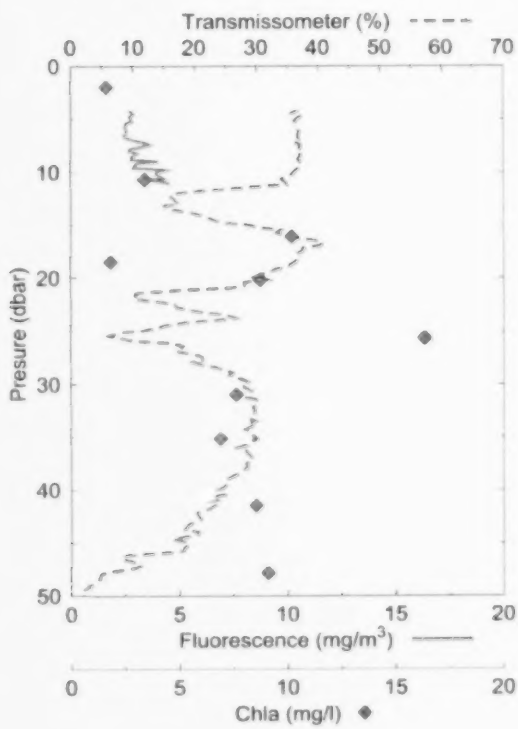
Date/Time: Jul 16 2003 22:33UTC

Position: 65° 41.94'N, 168° 42.82'W







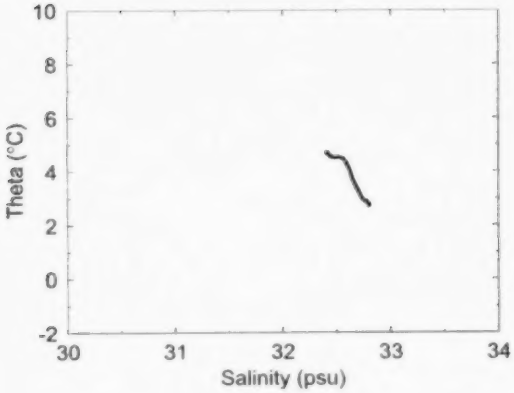


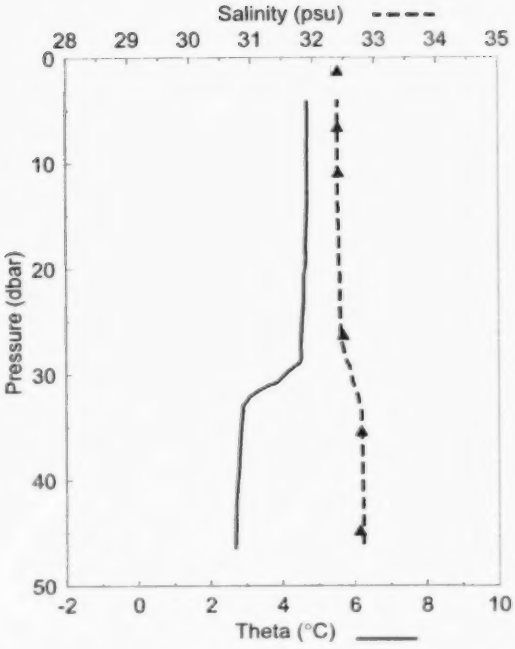
Cruise: 2003-18

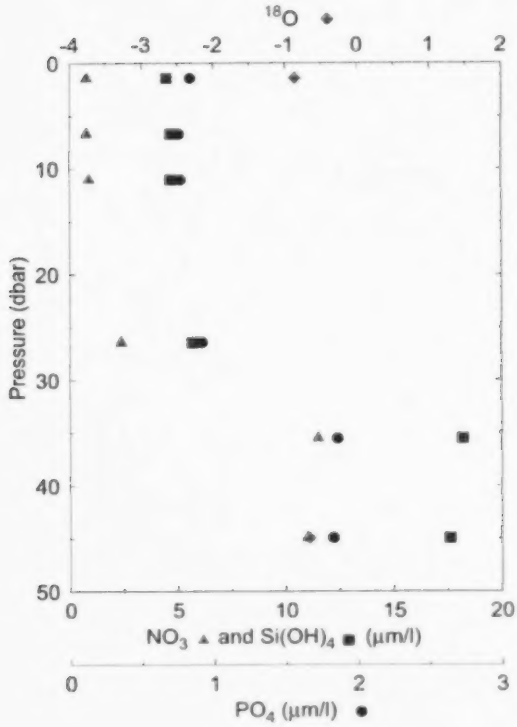
Cast: 22, Station: BRS5

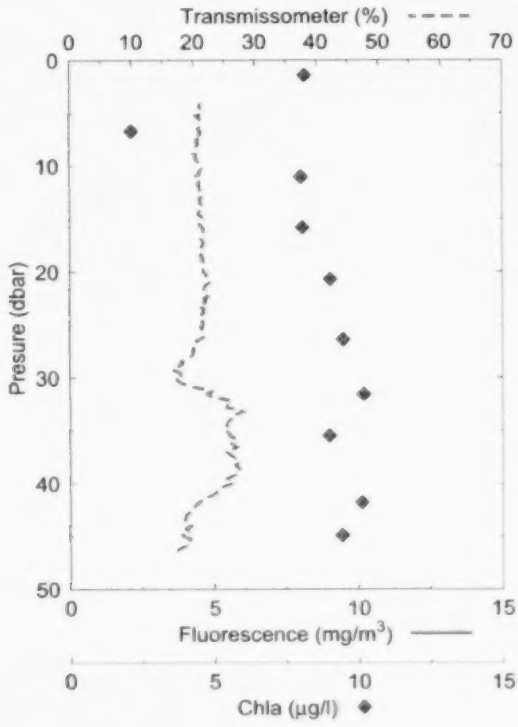
Date/Time: Jul 16 2003 23:46UTC

Position: 65° 42.95'N, 168° 53.77'W







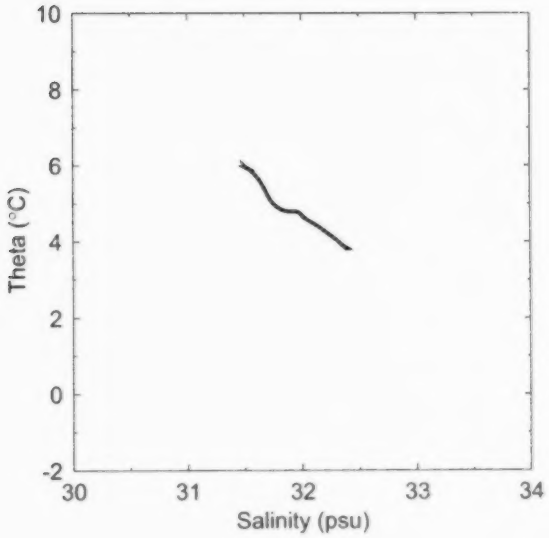


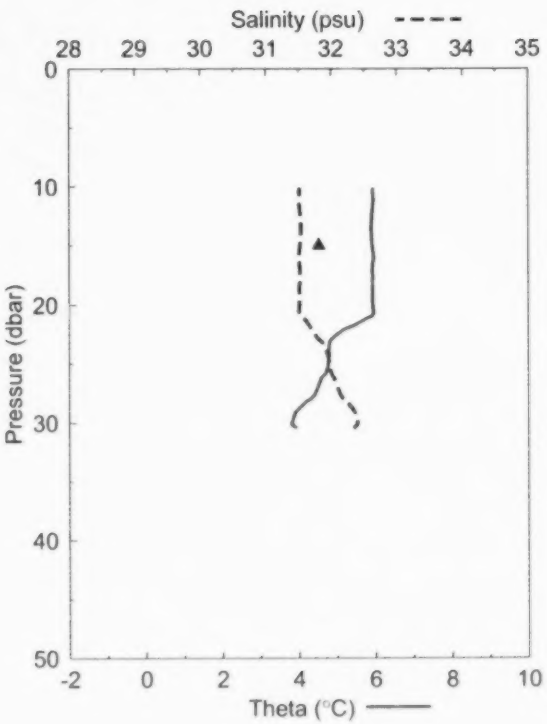
Cruise: 2003-18

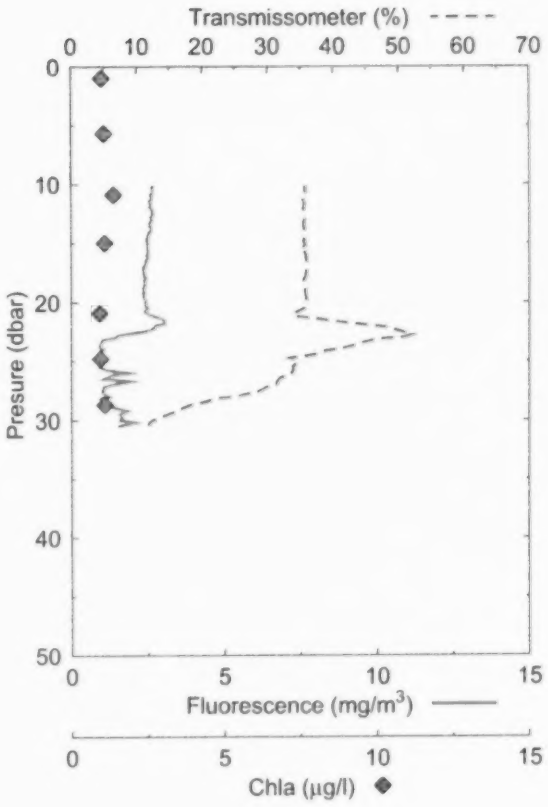
Cast: 23, Station: UTN-1

Date/Time: Jul 18 2003 03:55UTC

Position: 66° 42.46'N, 168° 23.97'W





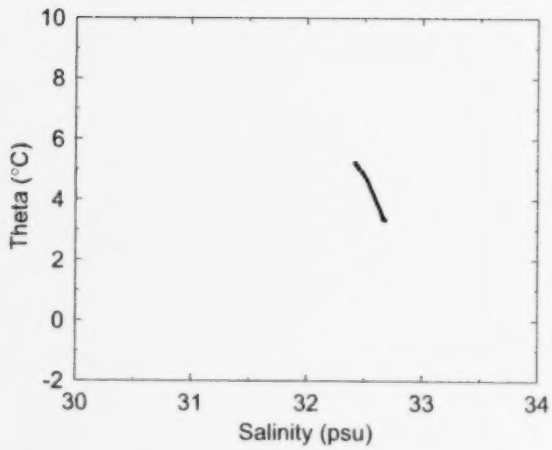


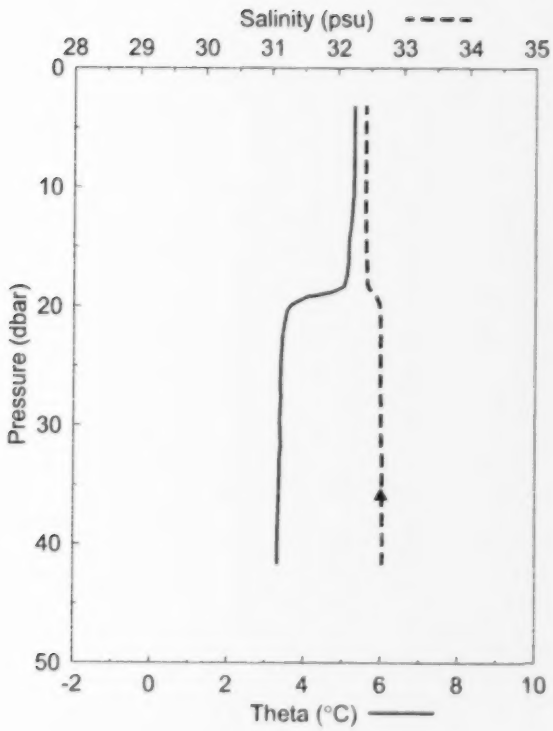
Cruise: 2003-18

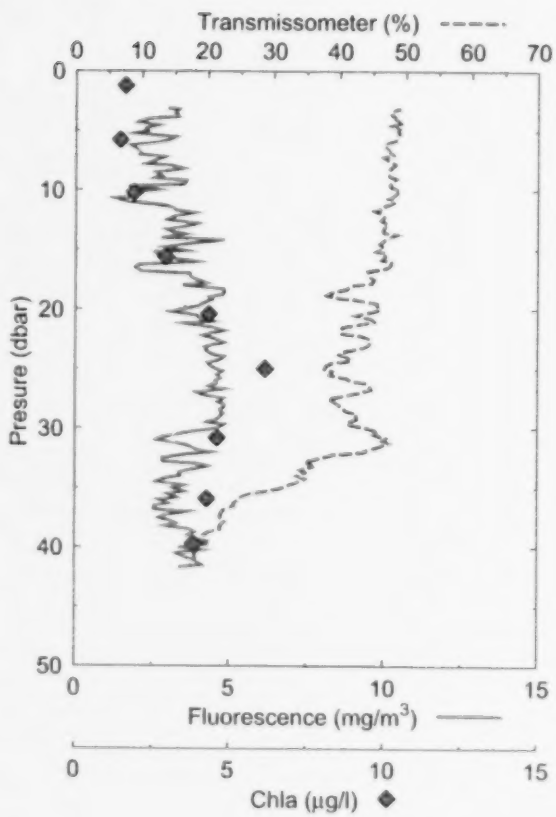
Cast: 24, Station: UTN-2

Date/Time: Jul 18 2003 12:14UTC

Position: 67° 3.09'N, 168° 44.09'W





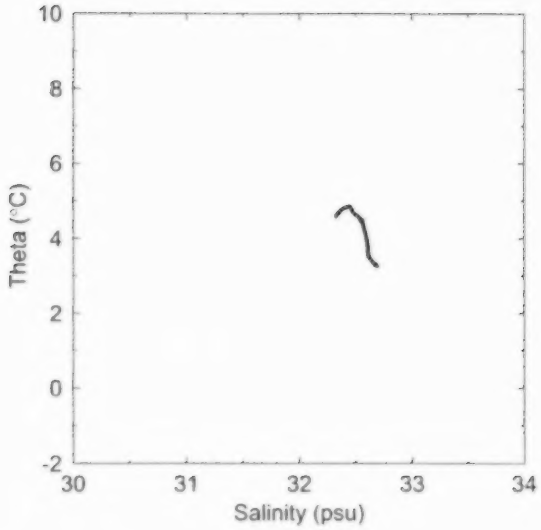


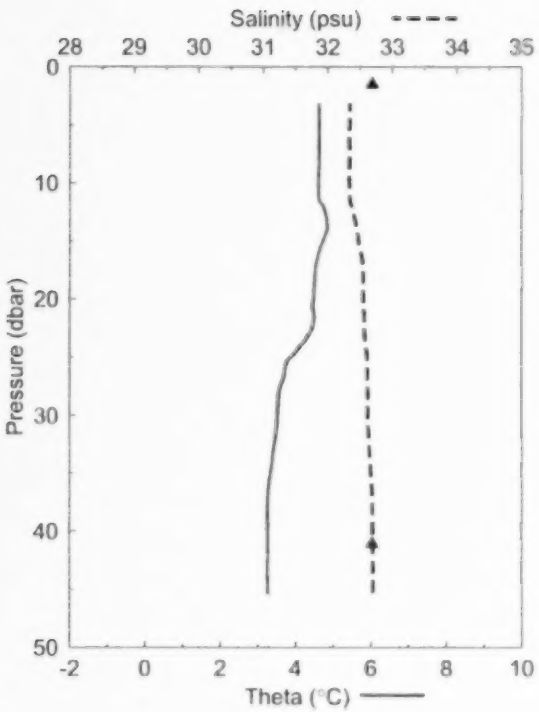
Cruise: 2003-18

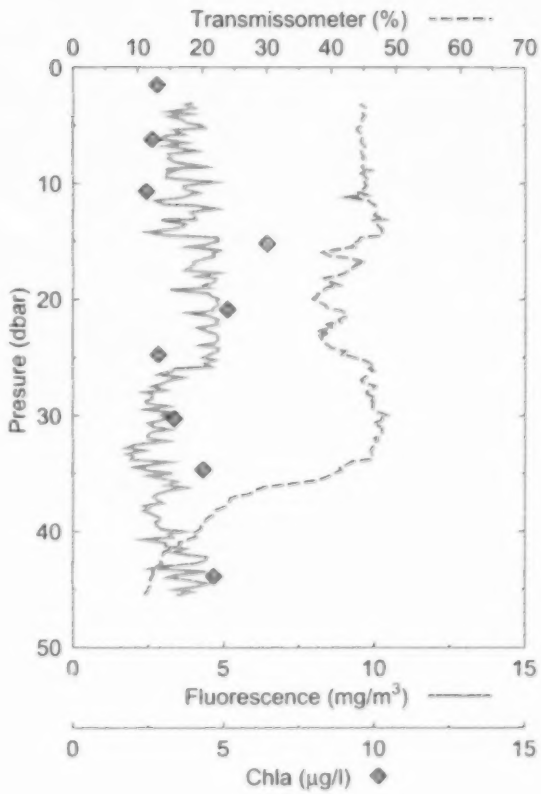
Cast: 25, Station: UTN-3

Date/Time: Jul 18 2003 14:10UTC

Position: 67° 19.87'N, 168° 59.94'W





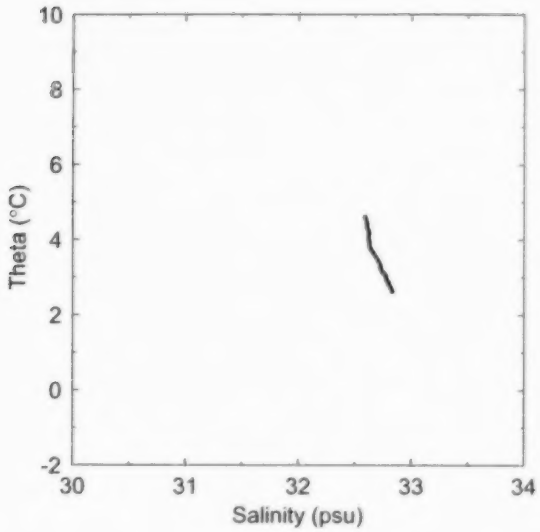


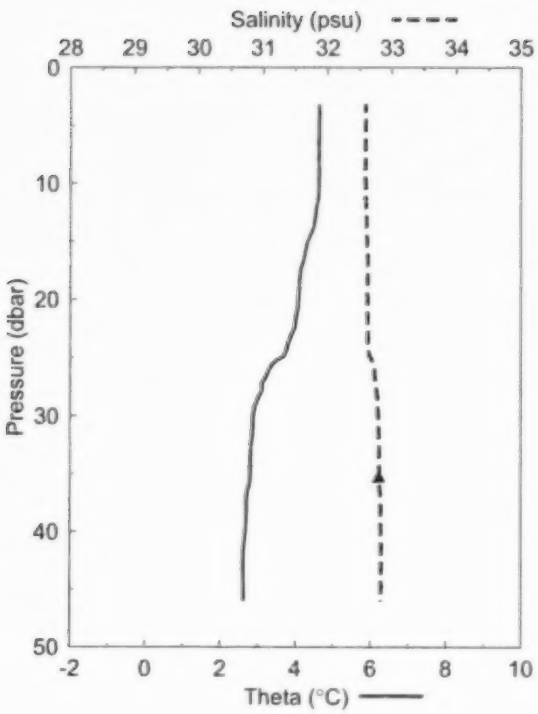
Cruise: 2003-18

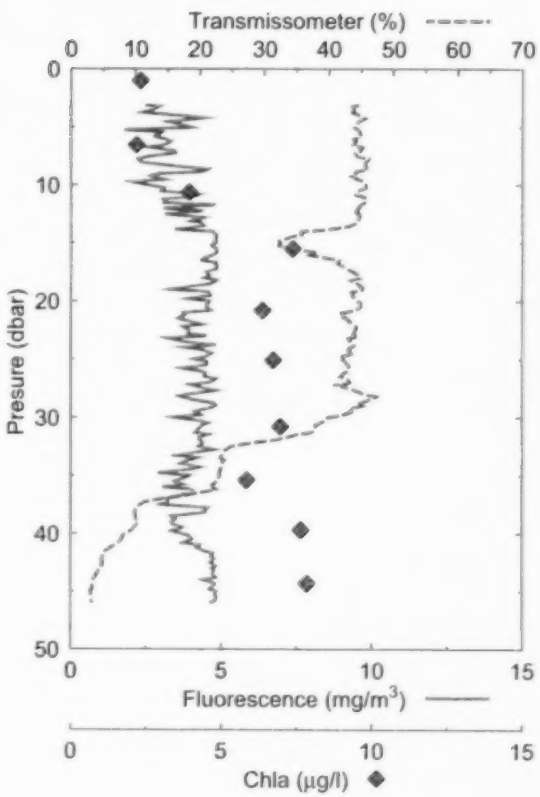
Cast: 26, Station: UTN-4

Date/Time: Jul 18 2003 16:13UTC

Position: 67° 30.12'N, 168° 54.74'W





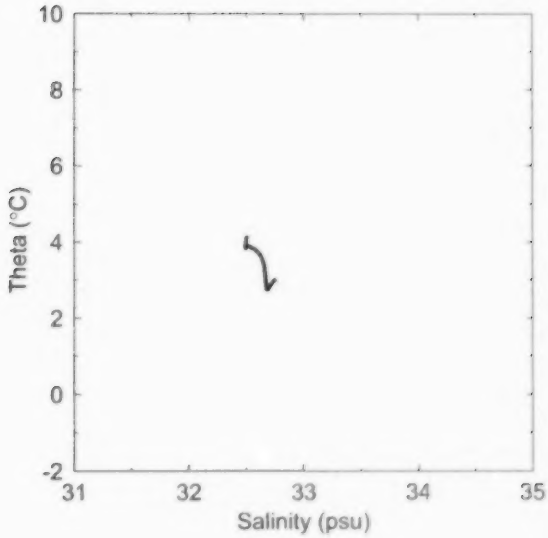


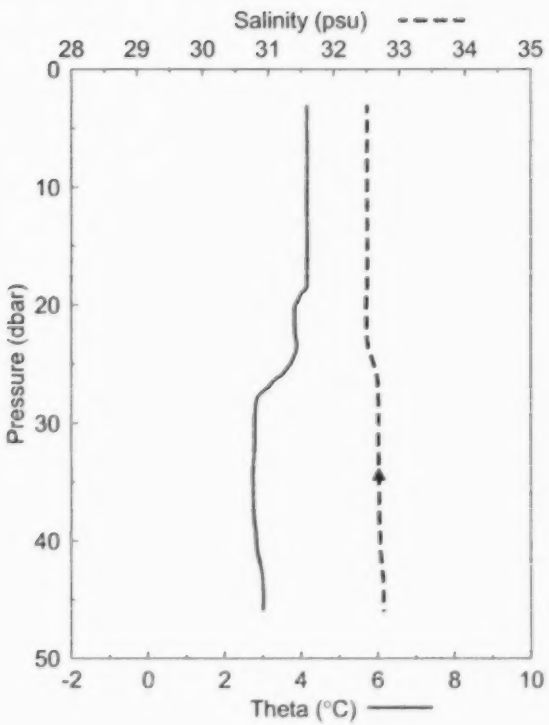
Cruise: 2003-18

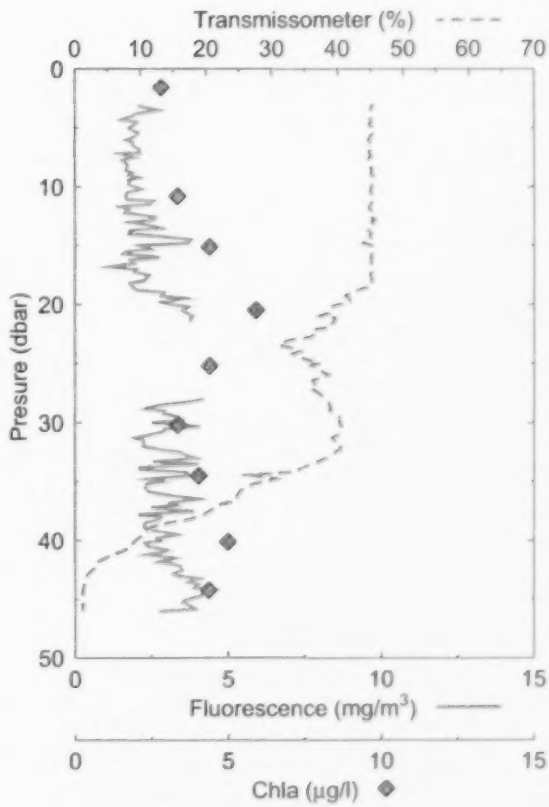
Cast: 27, Station: UTN-5

Date/Time: Jul 18 2003 18:13UTC

Position: 67° 40.23'N, 168° 52.45'W





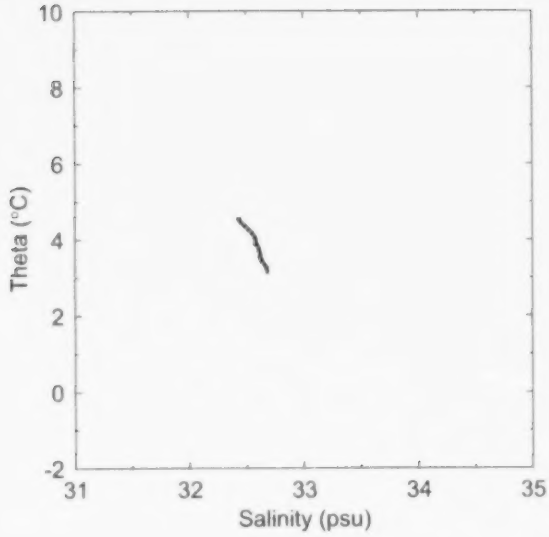


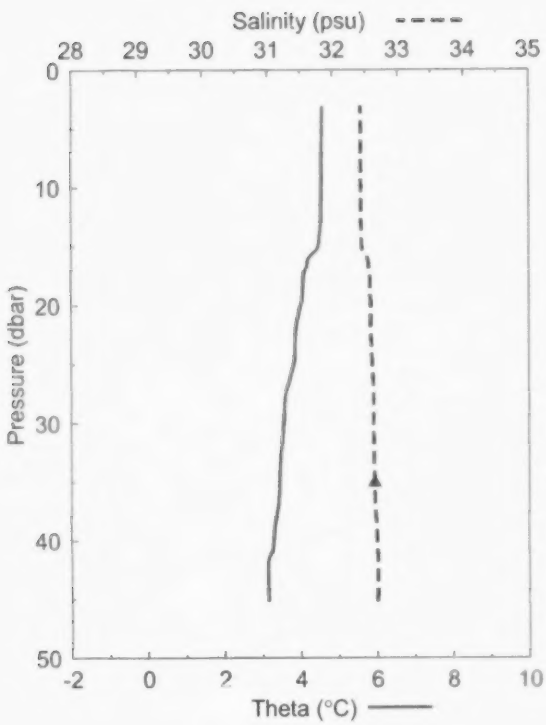
Cruise: 2003-18

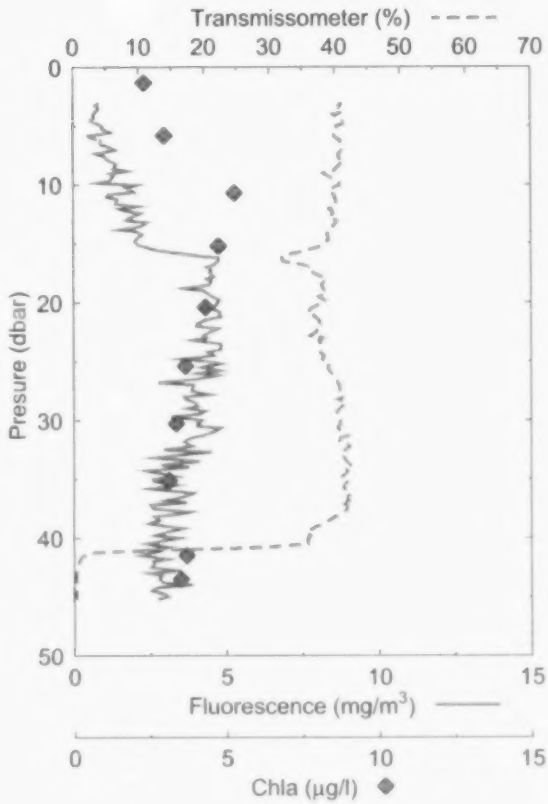
Cast: 28, Station: UTN-6

Date/Time: Jul 18 2003 21:21UTC

Position: 67° 40.24'N, 168° 57.34'W





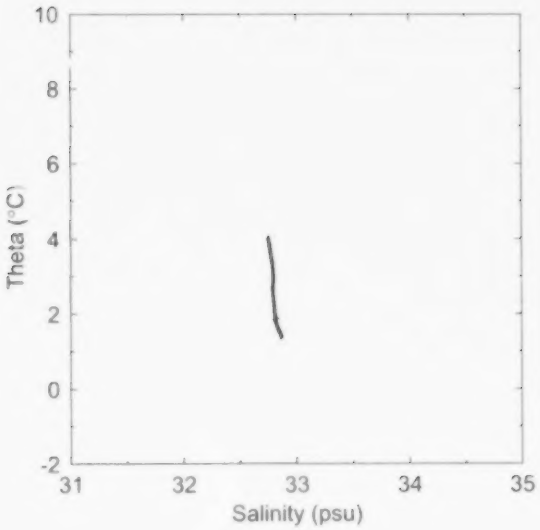


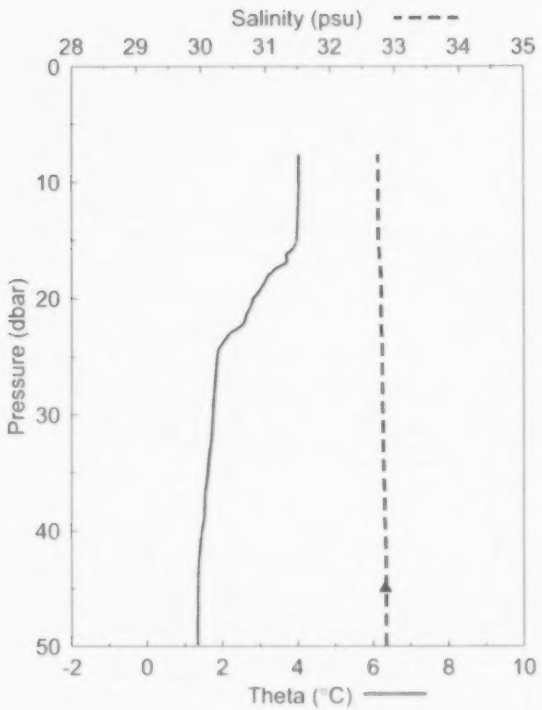
Cruise: 2003-18

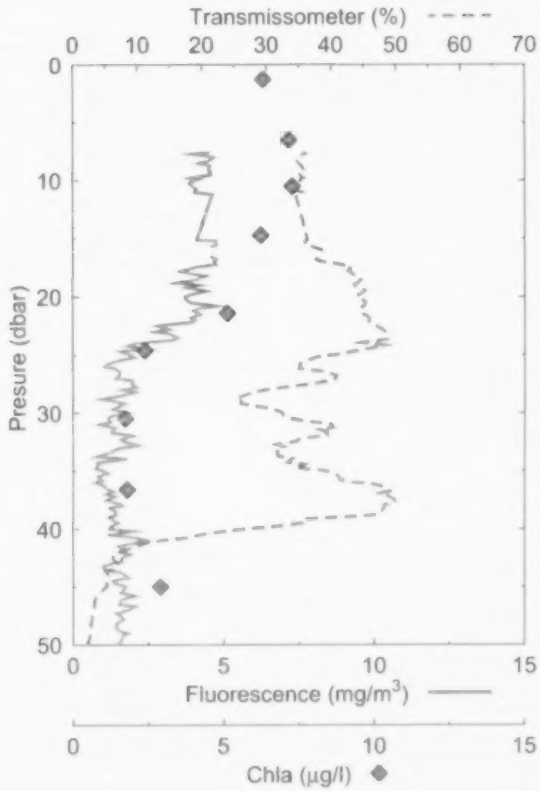
Cast: 29, Station: UTN-7

Date/Time: Jul 19 2003 00:11UTC

Position: 67° 59.97'N, 168° 55.78'W





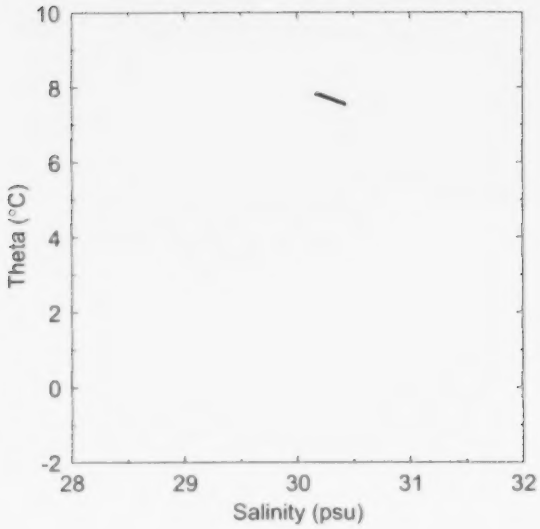


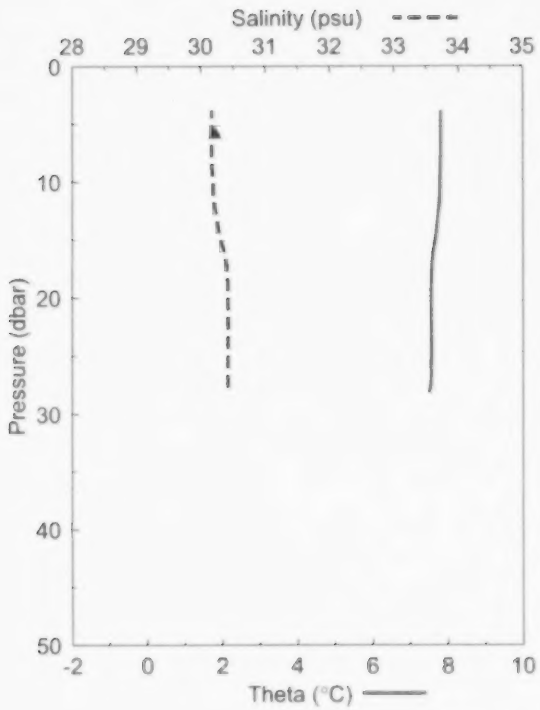
Cruise: 2003-18

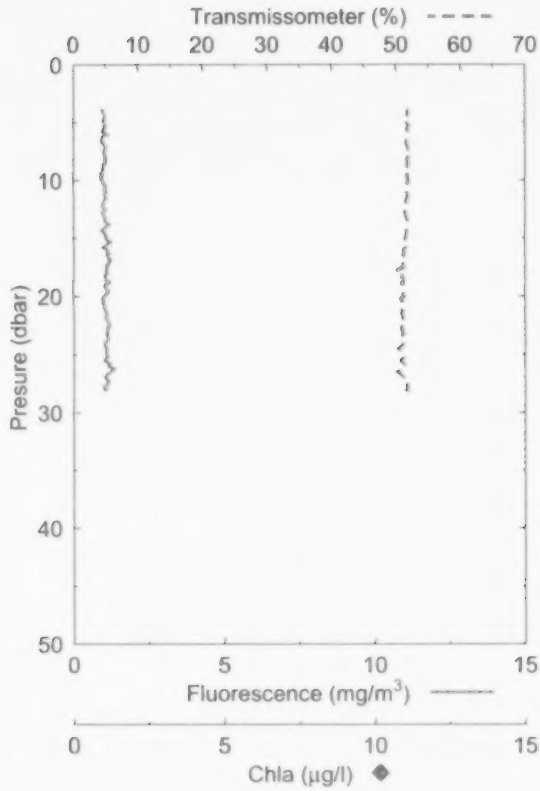
Cast: 30, Station: BD-6

Date/Time: Jul 19 2003 09:50UTC

Position: 69° 11.95'N, 166° 8.87'W





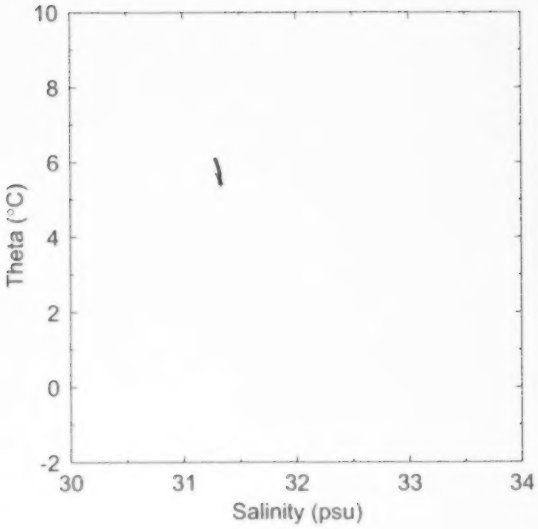


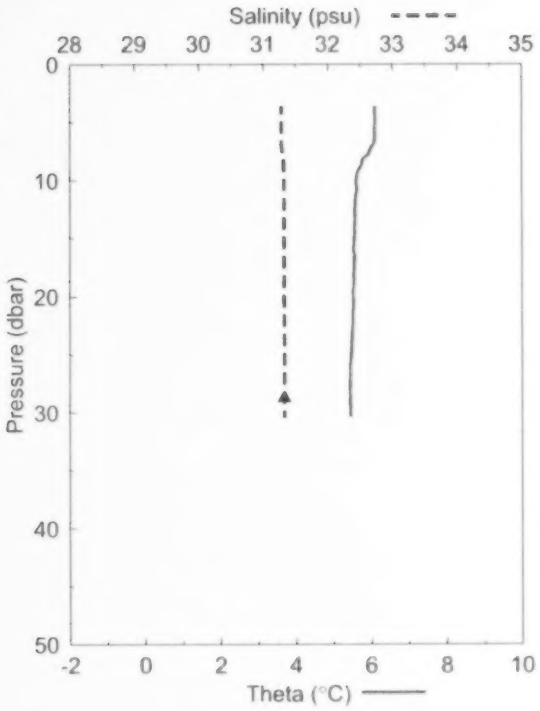
Cruise: 2003-18

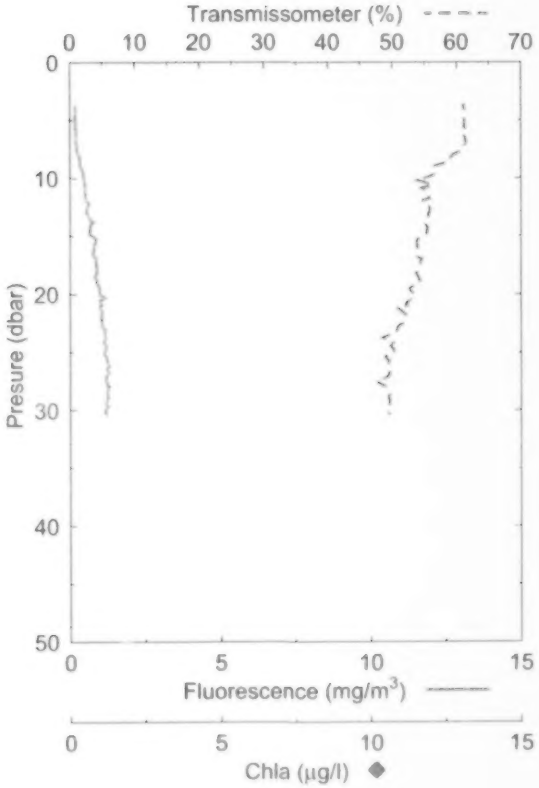
Cast: 31, Station: CKS-1

Date/Time: Jul 19 2003 23:17UTC

Position: 70° 37.02'N, 161° 6.58'W





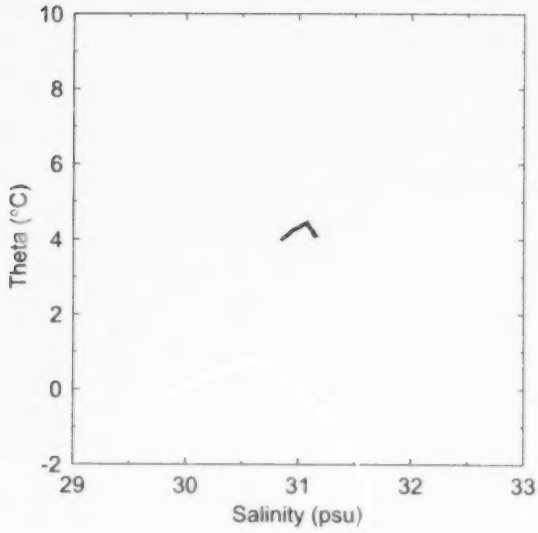


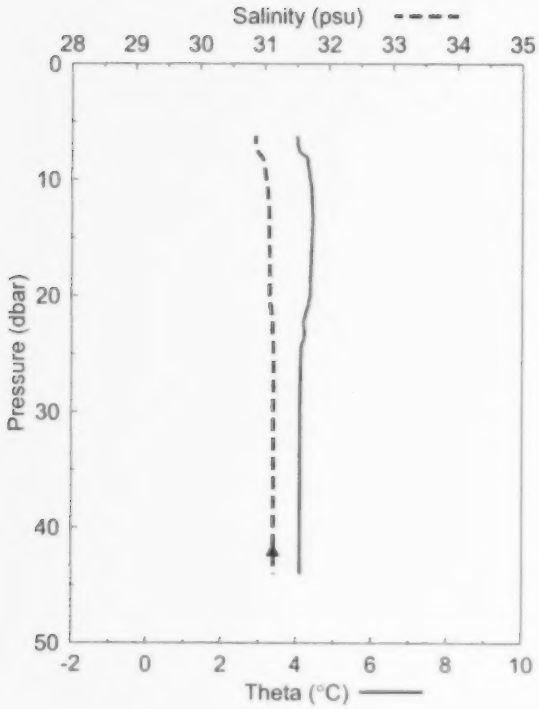
Cruise: 2003-18

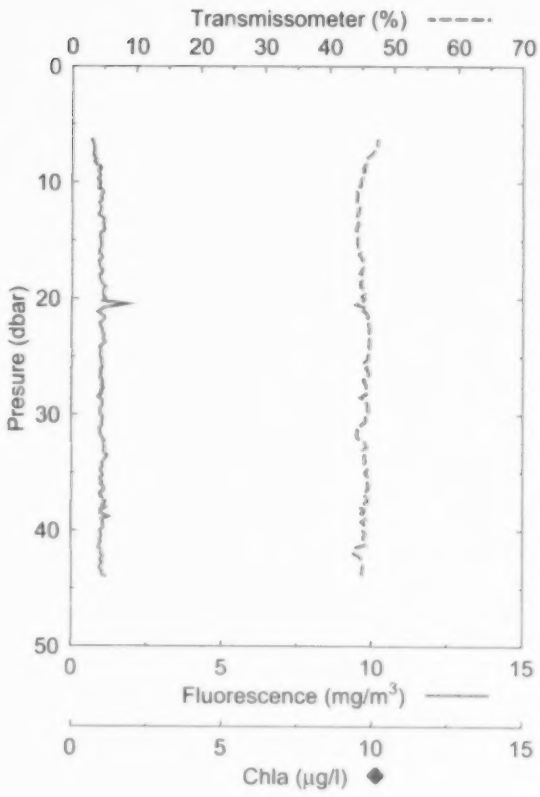
Cast: 32, Station: BD-7

Date/Time: Jul 20 2003 04:44UTC

Position: 71° 9.50'N, 158° 23.80'W





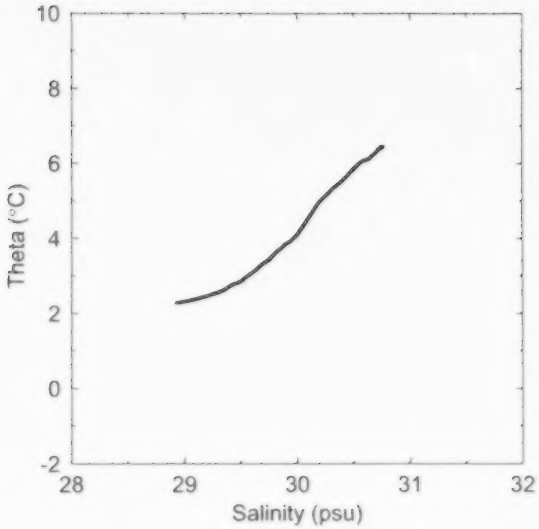


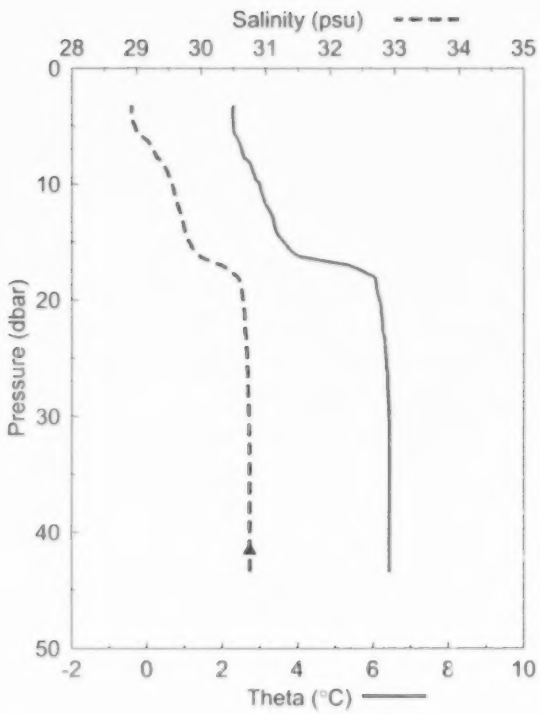
Cruise: 2003-18

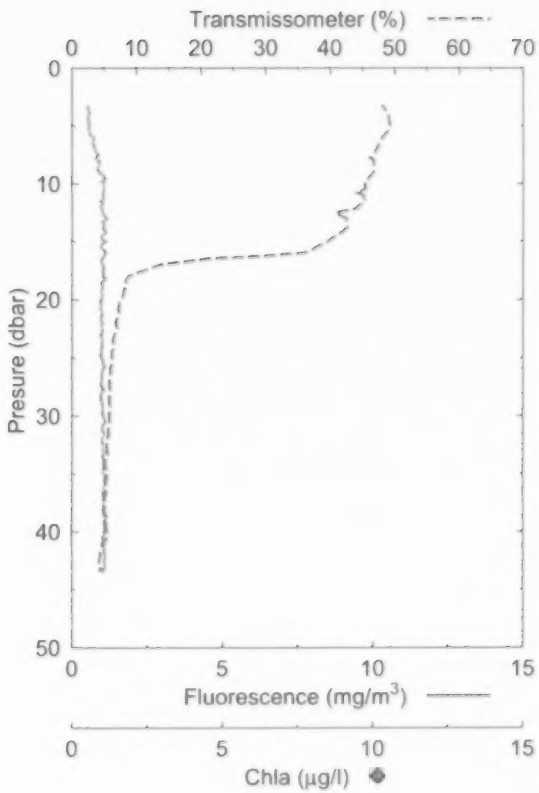
Cast: 33, Station: BD-8

Date/Time: Jul 20 2003 07:19UTC

Position: 71° 17.87'N, 157° 1.01'W







The plots on the following pages show sections from the CTD data for temperature, salinity, fluorometer, and transmissometer, and from the bottle sample nutrient analysis of Bering Strait stations BRS1-BRS5.

a for all stations along the ship's track, south to north (figure 5)

b at the section across the eastern half of the Bering Strait

CTD sensor parameters (figure 6)
& Nutrients bottle samples (figure 7)

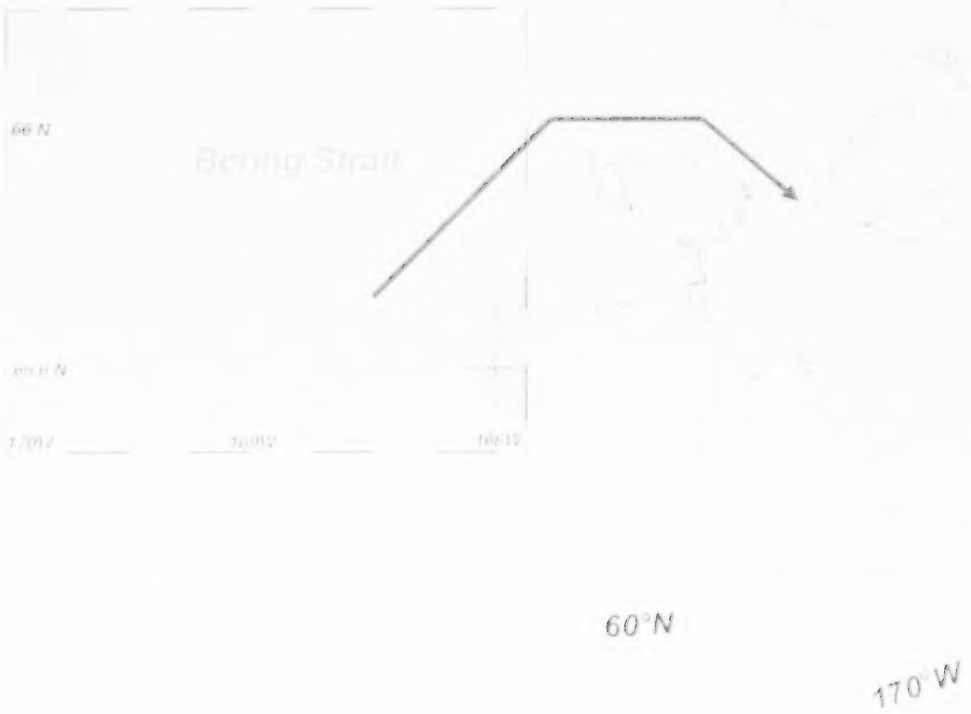


Figure 4: Maps of stations in data sections

The plots on the following pages show sections from the CTD data for temperature, salinity, fluorometer, and transmissometer, and from the bottle sample nutrient analysis of Bering Strait stations BRS1-BRS5

a. for all stations along the ship's track, south to north (figure 5),

b. at the section across the eastern half of the Bering Strait:

CTD sensor parameters (figure 6)
& Nutrients bottle samples (figure 7).

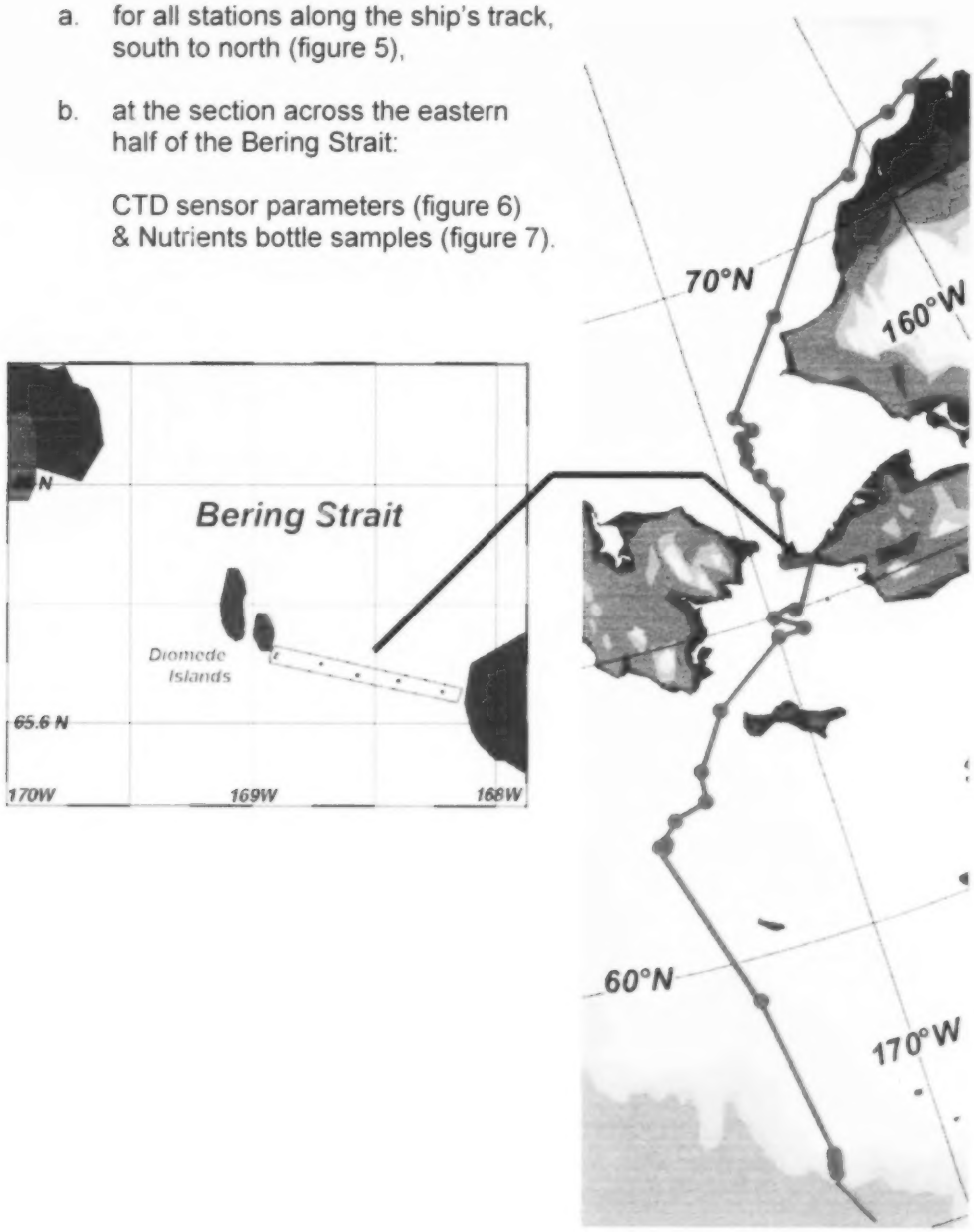


Figure 4. Maps of stations in data sections.

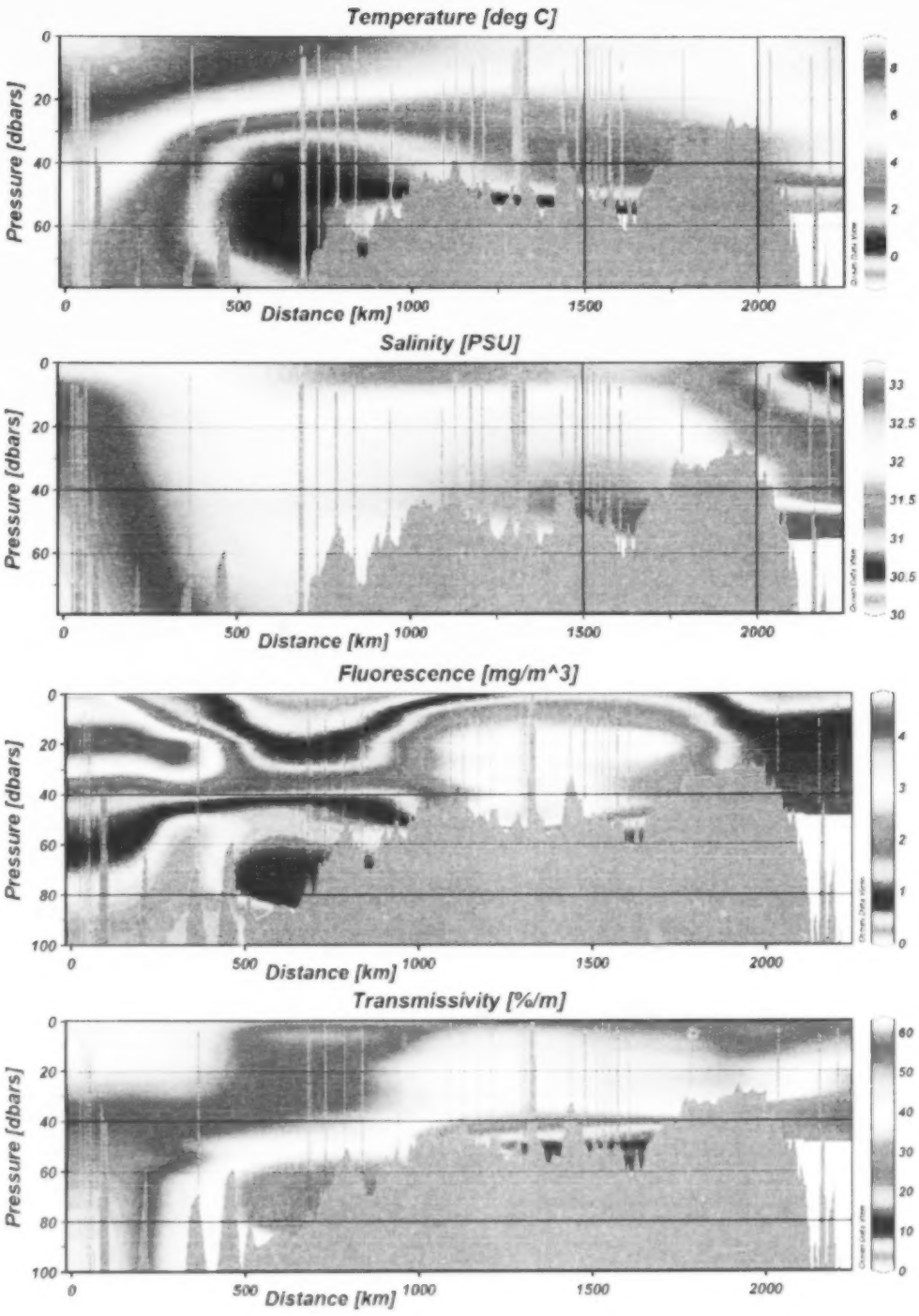


Figure 5. Bering & Chukchi Sea data sections of temperature, salinity, fluorescence and transmissivity along the ship's track.

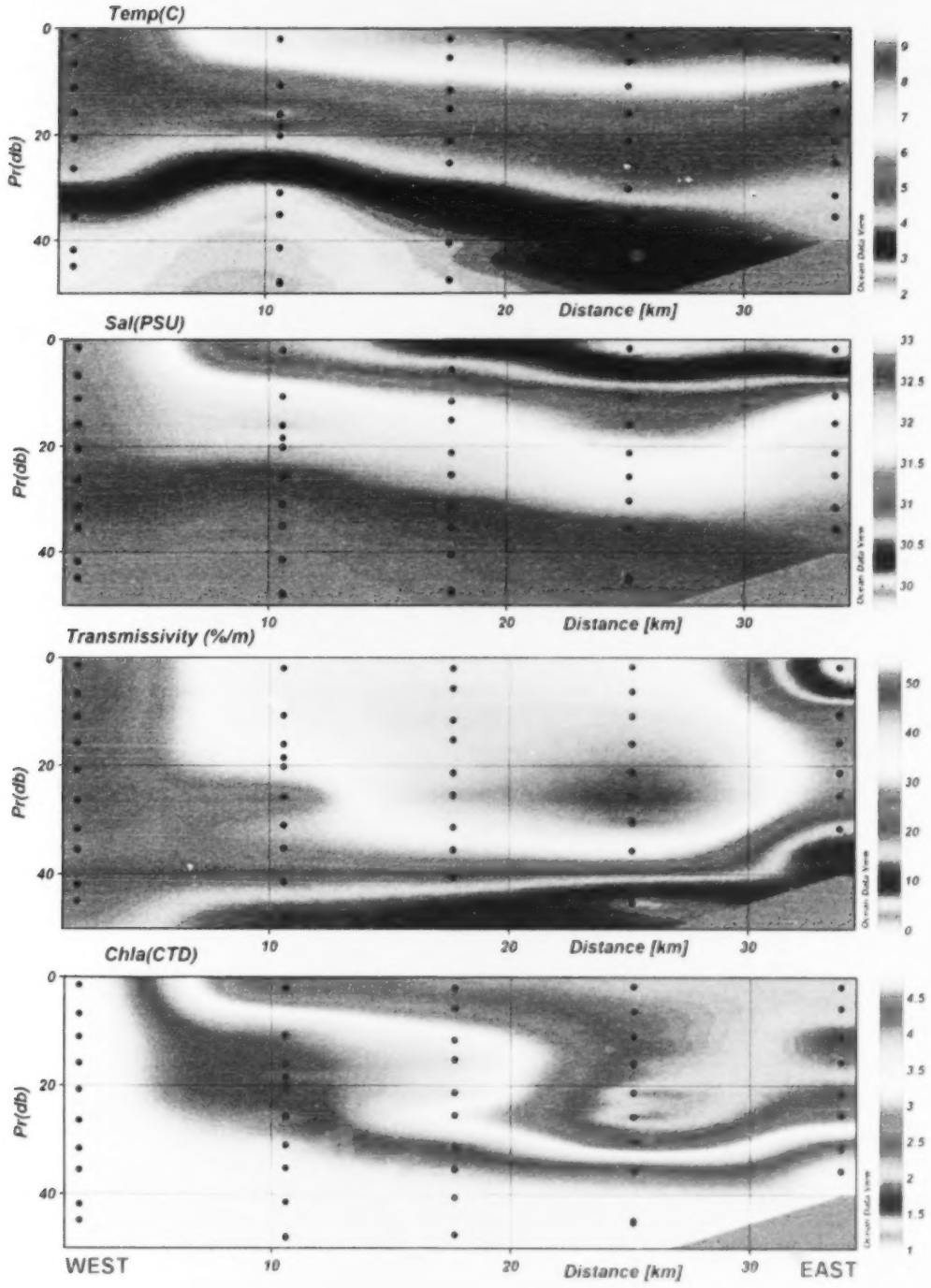


Figure 6. Bering Strait data sections of temperature, salinity, Transmissivity and chlorophyll from CTD data.

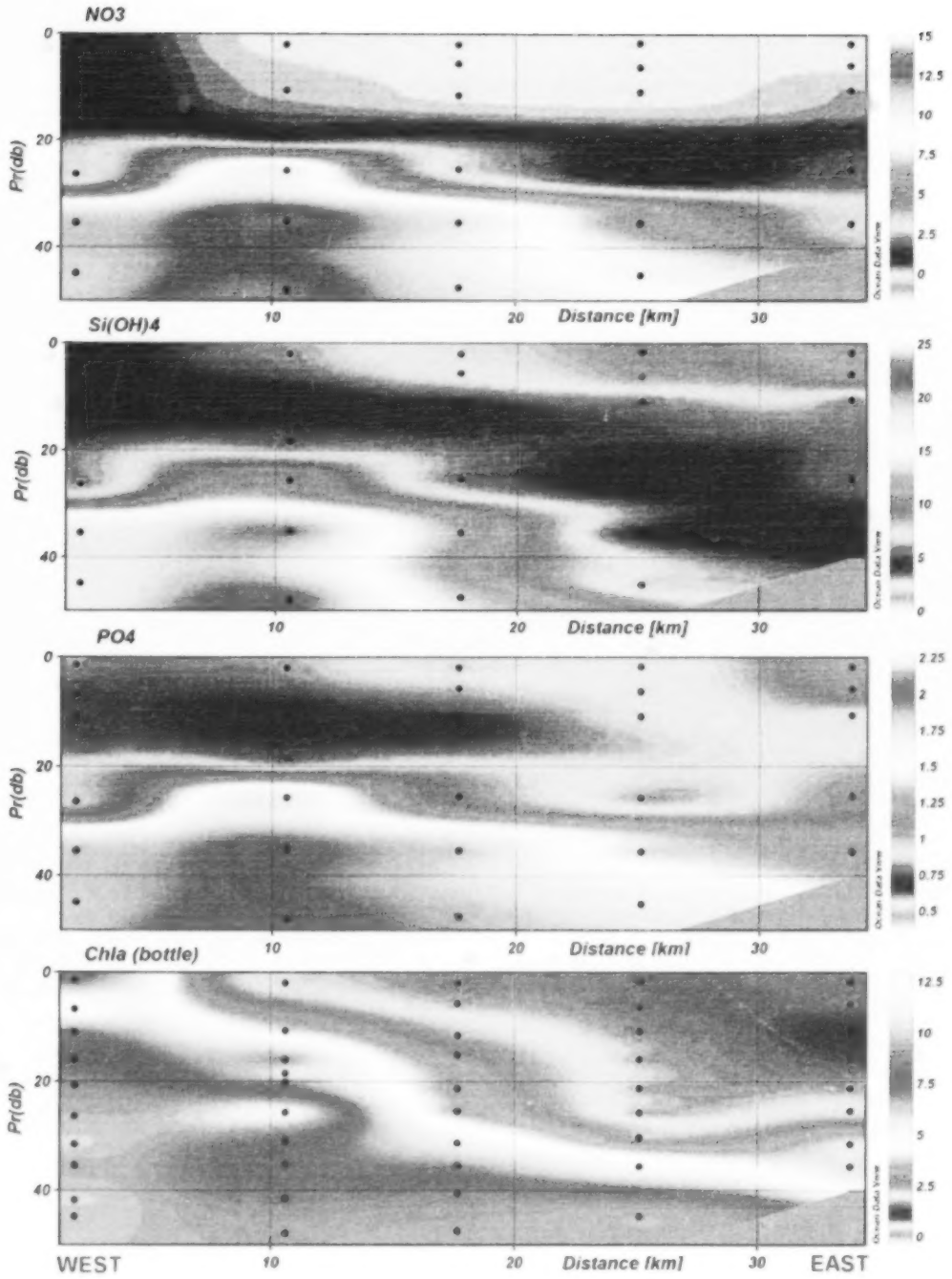


Figure 7. Bering Strait data sections of nutrients and bottle chlorophyll-a.

APPENDIX 8. BENTHIC DATA DISTRIBUTIONS

The plots on the following pages show distributions of benthic properties:

- bottom water temperature, salinity and nutrients,
- chlorophyll-a at the bottom and integrated through the water column, and mean concentrations & standard deviations in sediment from van Veen grabs and HAPS cores,
- total organic nitrogen, total organic carbon, and C/N ratio in the sediment and and oxygen respiration rates of sediment cores with standard deviation,
- Infaunal abundance, biomass (wet and gC/m^2), number of taxa, and the Shannon-Weaver Index & Evenness parameters,
- Sediment grain size distribution by modal value and by Krumbein phi-scale: phi = - $\log_2 D/D_0$ (where D is particle diameter, D_0 reference dia.)

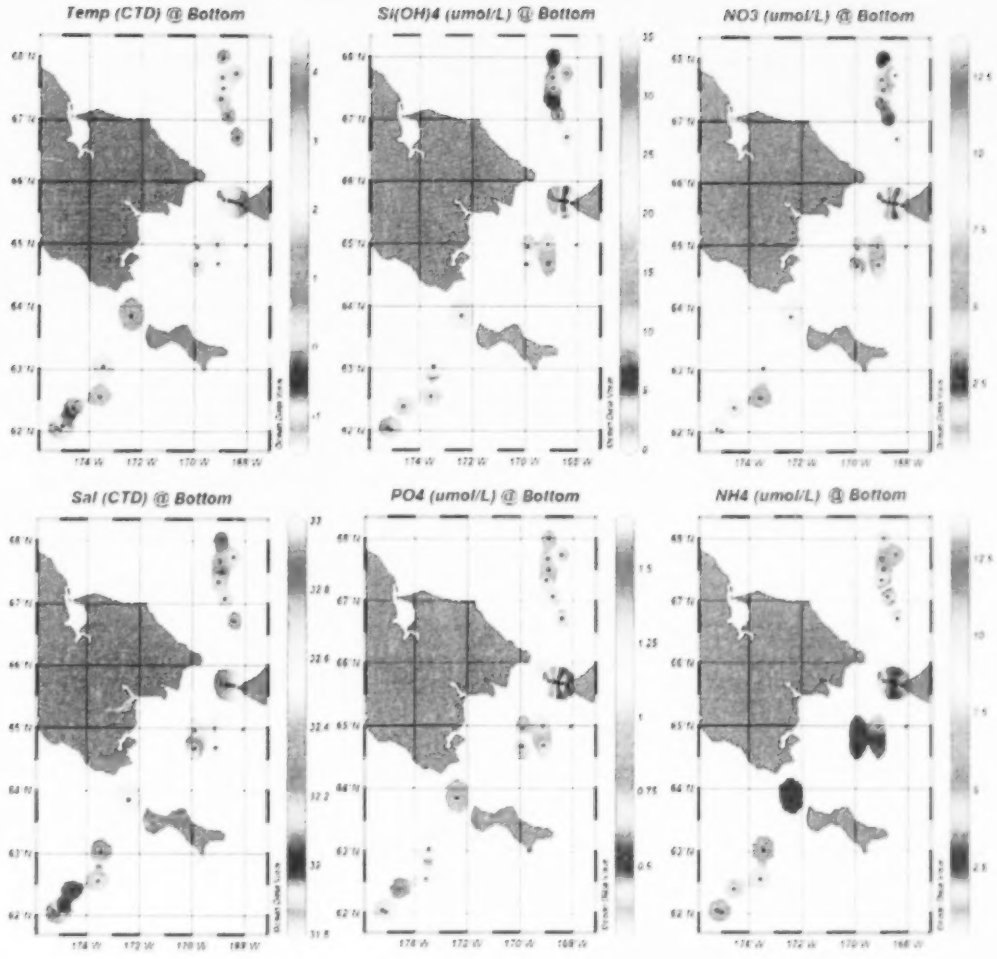


Figure 8. Bottom water: values for temperature, salinity, nutrients and methane (Grebmeier).

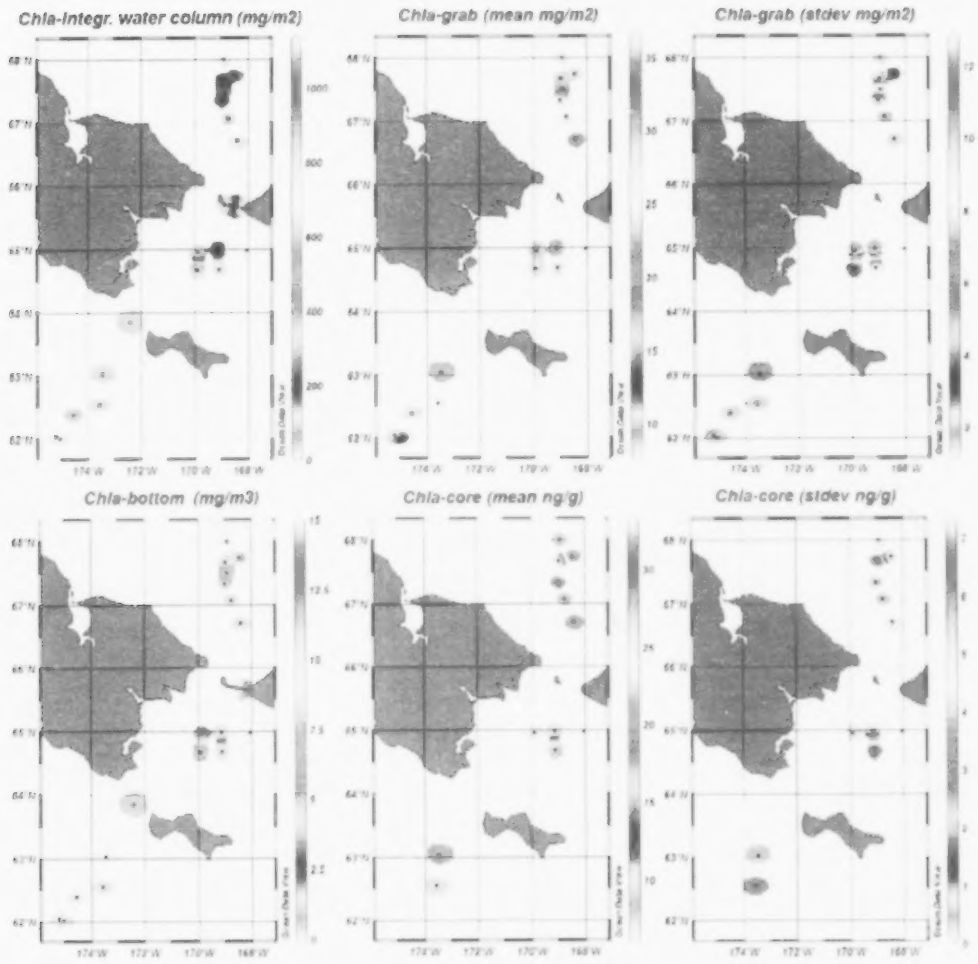


Figure 9. Chlorophyll-a in bottom water sample, integrated over the water column, and from van Veen grabs and HAPS cores - the latter both with respective standard deviations.

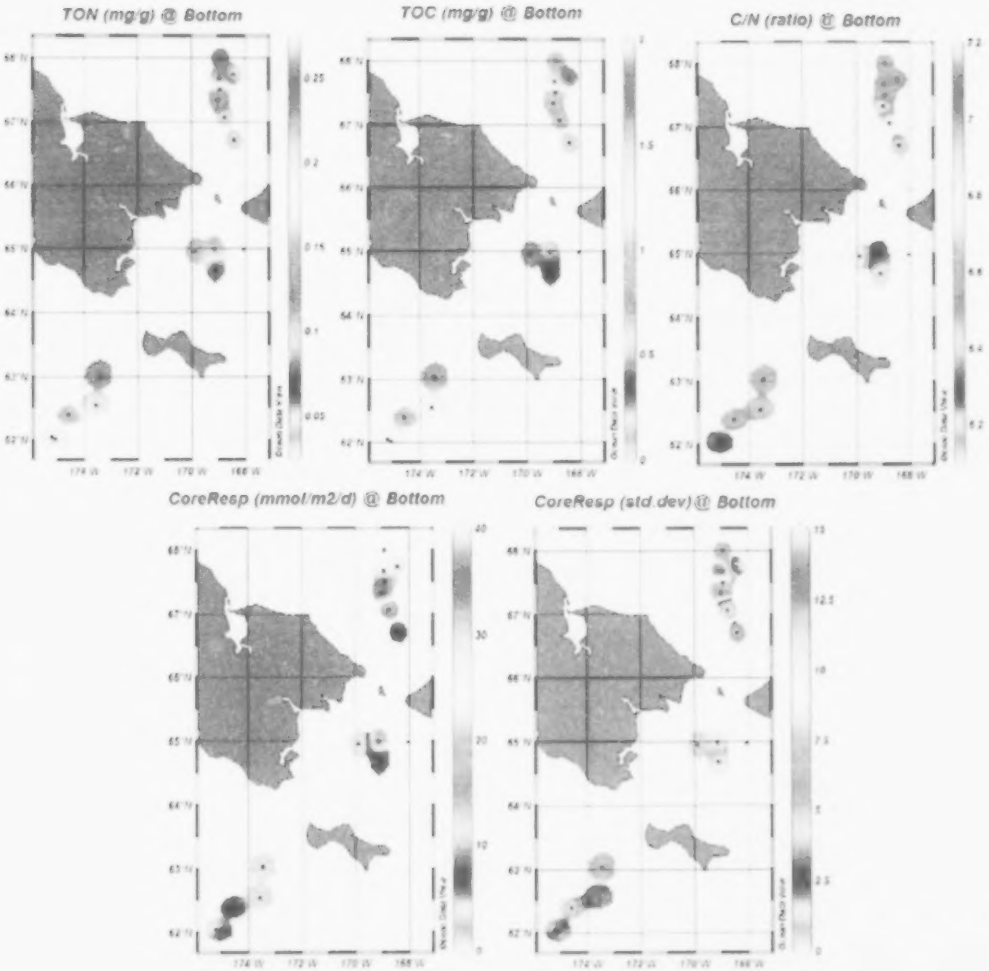


Figure 10. Sediment total organic nitrogen, organic carbon, and C/N ratio (top row) and oxygen respiration rates of sediment cores with standard deviation.

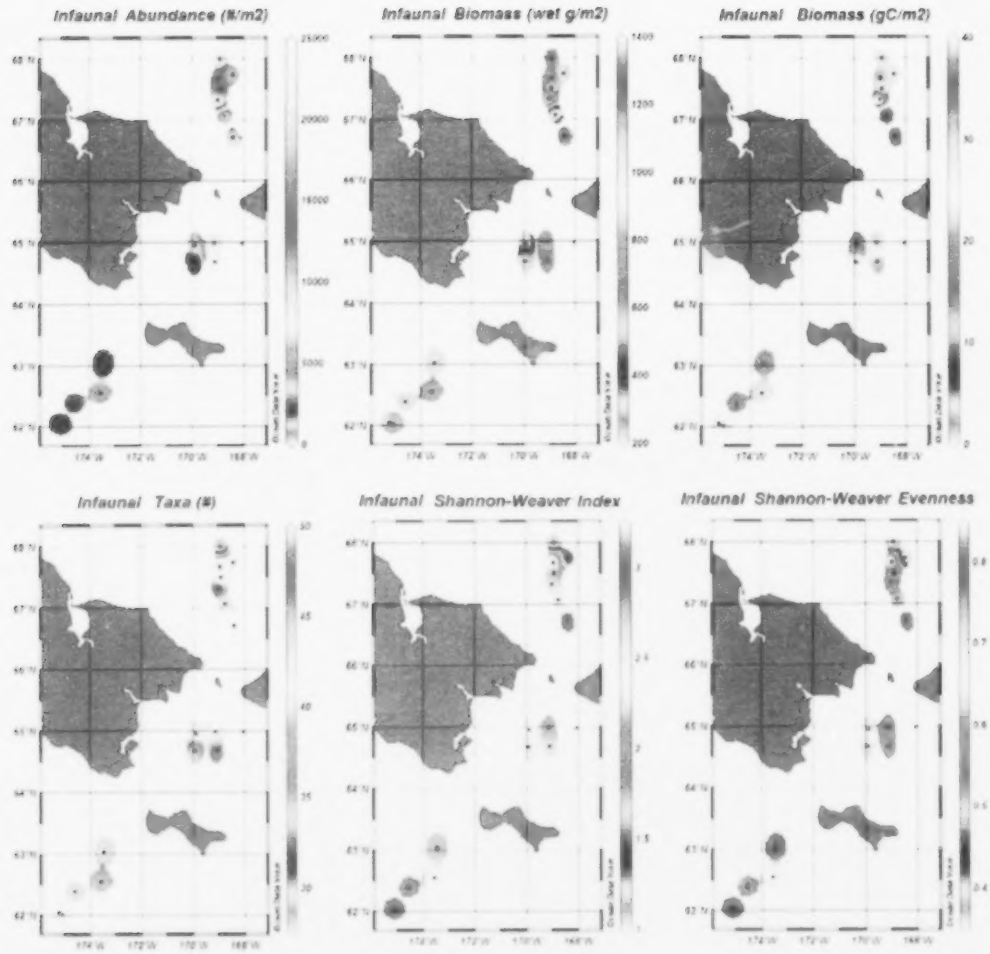


Figure 11. Infaunal abundance, biomass (wet and gC/m^2), number of taxa, and the Shannon-Weaver Index & Evenness.

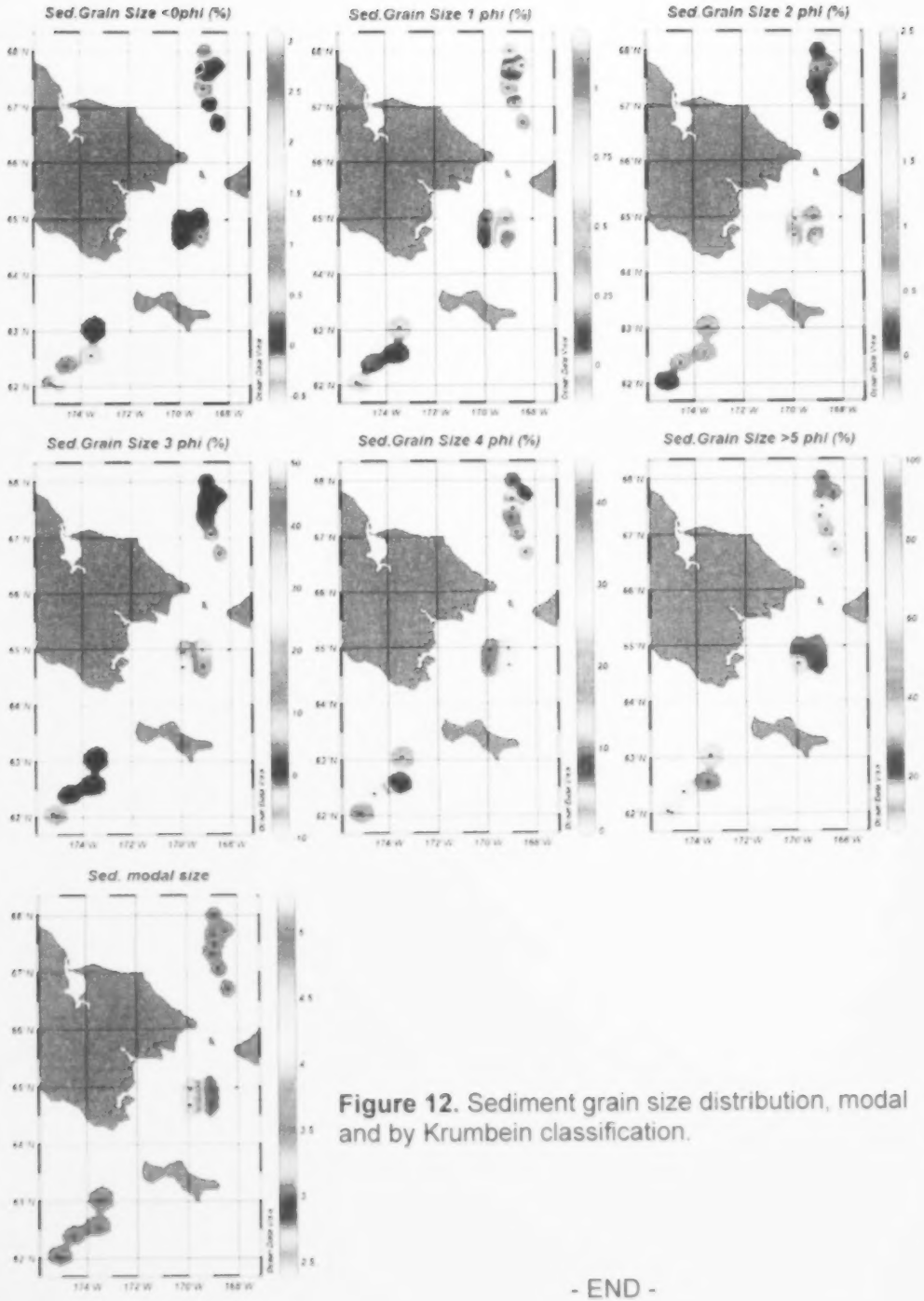


Figure 12. Sediment grain size distribution, modal and by Krumbein classification.

- END -